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VOL. IV, NO. 4 OCTOBER, 1922 Old Series: Vol. xx, No. 4

The Journal of Bone & Joint Surgery

HEMORRHAGIC OSTEOMYELITIS.*

BY GEORGE BARRIE, M.D., F.A.C.S., NEW YORK CITY.

THE importance of the lesion in bone termed Hemorrhagic Osteomyelitis appears to be now well recognized, its benign condition quite established, and its characteristic features of a mild inflammatory affection definitely proven by the gross and microscopic criteria presented by the process.

The purpose of this paper is to emphasize particularly the above facts, rather than to offer anything especially new at this time, and to give in brief outline our present-day knowledge which careful study of the lesion has gradually developed.

Until ten years ago there was universal acceptance of the dogmatic assertions that this pathologic process in bone was malignant and that it required the standardized operative surgical measures accorded neoplastic disease for its eradication. Amputations of limbs were commonly resorted to and resultant cures heralded as achievements in overcoming malignancy. Many statistical tables published in the past reporting cures of bone sarcoma owe their greatly increased percentage of cures to the inclusion in such statistical tables of lesions in bone which we know now were not malignant or even blastomatous. All scientific

*Read at the meeting of the American Orthopedic Association, held at Washington, D. C., May 1-3, 1922.

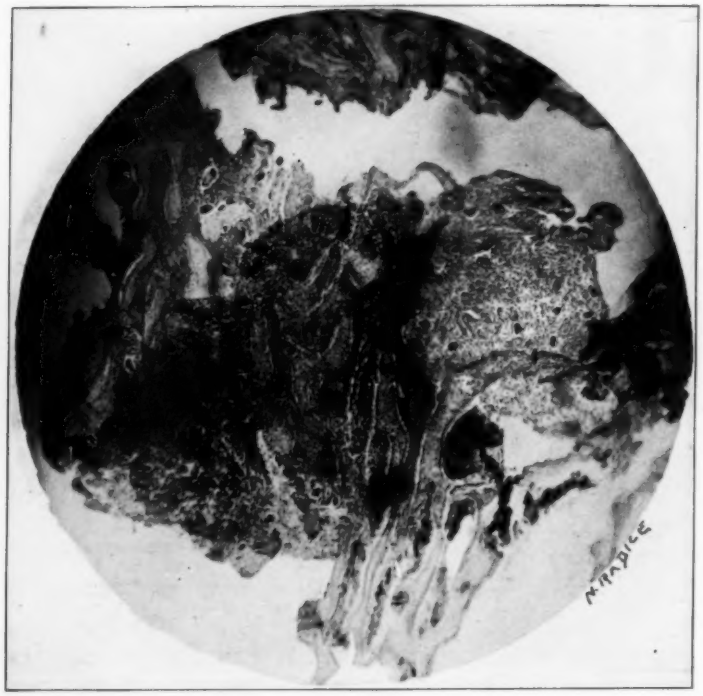

FIGURE 1.—Photomicrograph, low power, showing a typical microscopic picture of hemorrhagic osteomyelitis, miscalled giant-cell sarcoma and giant-cell tumor. Note the basic granulation tissue structure, scattered scavenger giant cells, and disintegrated bone.

methods of search and investigation demonstrate that this process in spongy bone, heretofore described as sarcoma, parallels and coincides in all its stages with the varying phases of non-suppurative inflammatory change. In spite of such evidence there are many surgeons who, even today, regard these lesions with great suspicion and adopt the slogan "when in doubt eradicate," which they certainly accomplish when they amputate portions of, or whole, extremities.

This deplorable attitude is due, in large measure, to the expression of opinion by many surgeons, pathologists, and radiologists that these benign inflammatory masses, found in destroyed bone areas, are neoplastic growths, which they term either giant-cell sarcomata or giant-cell tumors. The presenting evidence in all such cases, of an effort at regenerative repair and restoration of structure, appears to be quite overlooked or ignored.

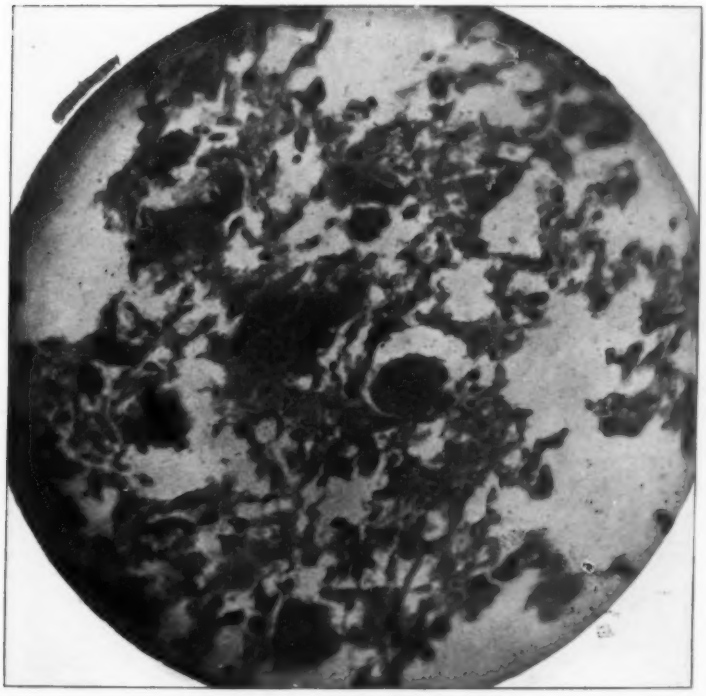

FIGURE 2.—Photomicrograph, high power, showing in detail the scavenger (foreign body) cells. These cells are sometimes present in great numbers in localized areas of hemorrhagic osteomyelitis containing sterile débris. Note the number of nuclei within the cell, the uniform size and shape of the nuclei, the absence of fibrils and mitotic figures, all of which are in contra-distinction to the tumor giant cell. Scavenger giant cells arise from fusion of endothelial cells. They enclose, or absorb, foreign particles in the tissues.

Pathologists and surgeons, without exception, when they encounter tissue formation of similar structure occupying areas that have been destroyed in soft parts, have no hesitation in making diagnoses of exuberant inflammatory granulations. When exactly the same type of structure, both macroscopically and microscopically, presents itself as a mass within an enclosed bony shell, it is erroneously regarded as a neoplasm. In order to bolster up this theory of neoplasia, the innocent scavenger giant cells found in these lesions have been seized upon as the offenders, without any basic evidence whatever to show they are even a factor in tumor growth.

It has also been interesting to note that in numerous instances when an area of osteolysis is exposed where destruction does not exceed the

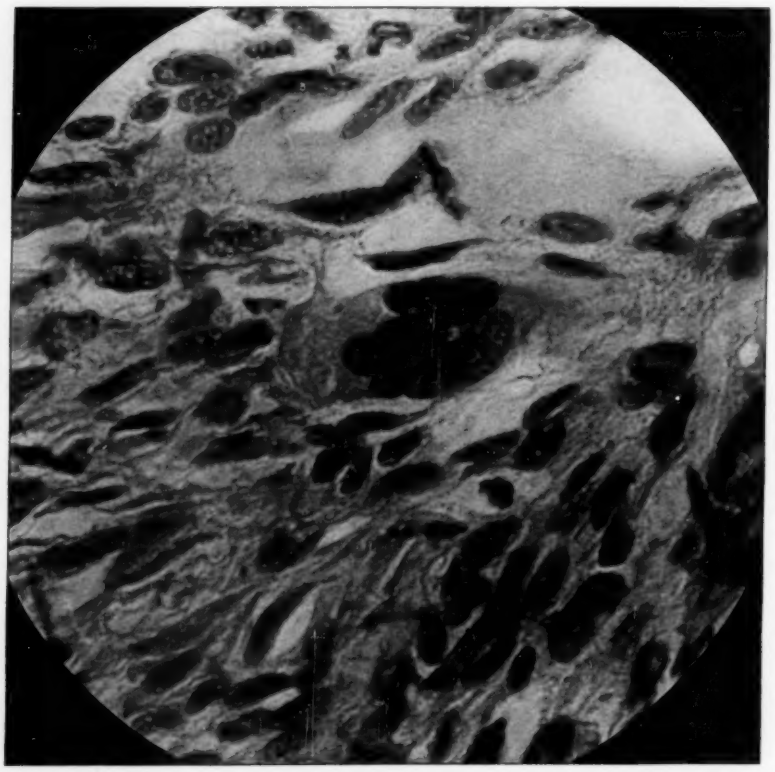

FIGURE 3.—Photomicrograph, high power, of a tumor giant cell. This type cell is never found in hemorrhagic osteomyelitis. It arises from multiple mitoses and denotes malignancy. Compare with the scavenger cell marked Figure 2. Note the few very large irregular lobulated nuclei and definitely different picture the tumor giant cell presents.

size of a cherry or plum, radiologists and surgeons seem quite generally to regard such lesions as bone cysts, notwithstanding the fact that the destroyed area at operation may be found filled with solid granulation tissue, and frequently without any appearance of lining membrane. Should the area of osteolysis happen to be the size of an orange, containing contents of exactly the same type of replacement granulation tissue, and also presenting a histologic picture exactly similar to the smaller lesions, there seems to be no hesitancy in describing the process as a giant-cell sarcoma or a giant-cell tumor. The inaccuracy in using such terms to describe these masses of regenerative tissue cannot be too strongly emphasized, because the affections never contain what are rec-

FIGURE 4.—Hemorrhagic osteomyelitis lower end right tibia. Male, age 38. Before operation.

ognized as giant tumor cells. On the other hand, scavenger, or foreign body, cells may be quite numerous in localized areas of the process. The presence of the latter indicates nature's method of removing the sterile débris contained in the lesions. In areas where regeneration and metaplasia are progressing, few or no giant cells are found. There is never a uniform picture of scavenger giant-cell content or arrangement in any of these lesions.

A recent paper on bone sarcoma, published by Greenough, Simmons and Harmer, brings out very well an important phase of the subject, as follows:

"Tumor giant cells are to be distinguished sharply from the typical foreign-body cells of endothelial origin which are encountered so frequently in all bone diseases, benign or malignant, and which are of practically no significance from the tumor point of view, however much they may impress themselves upon the observer in the microscopic sec-

FIGURE 5.—End-result 3 years after curettage by H. L. Taylor.

tions of the tissue, as in the miscalled 'giant cell sarcoma' of the epulis type.''

The proponents of a neoplastic or blastomatous theory of origin for the affection termed hemorrhagic osteomyelitis are in a very vulnerable position when they pin their faith upon the foreign body or scavenger giant-cell content as being factors in producing such lesions. From the time of Nélaton, in 1852, to the present moment no demonstrable proof has been adduced that giant cells, of the type found in these processes, are tumor-forming cells. Their function, however, as scavengers for the removal of sterile débris, is well recognized. Numerous studies and investigations leave no room for doubt that the functions of such cells are wholly scavenger. When their presence is observed in true blastomata, the type of cell that produces and forms the neoplasm itself should describe the process, and not the innocent scavenger giant cells. As has been pointed out in other papers covering the subject, the term giant-cell sarcoma and giant-cell tumor are misnomers, which should be discontinued. The tissue mass is not a result of giant-cell growth or of giant-cell origin.

FIGURE 6.—Hemorrhagic osteomyelitis lower end left tibia. Male, age 18 years. Before operation.

A knowledge of the inflammatory picture of the bone pathology of these cases which establishes their benign course should insure conservative surgical treatment. Much of the radical surgery that has been performed for the cure of these conditions rests at the door of pathologists, whose reports of malignancy or neoplasia have been quite general in the past. When they decide to drop the use of such terms as giant-cell sarcoma and giant-cell tumor in describing the process, and note instead the criteria the cellular pictures present of a low-grade inflammation or osteomyelitis, surgeons will recognize the benign character of the lesion and institute conservative methods of treatment.

Hemorrhagic osteomyelitis should not be regarded as a lesion of degenerative or destructive intent, but rather as nature's effort to form primary replacement tissue in a previously destroyed bone area. Such attempt may finally progress to full architectural restoration of bony

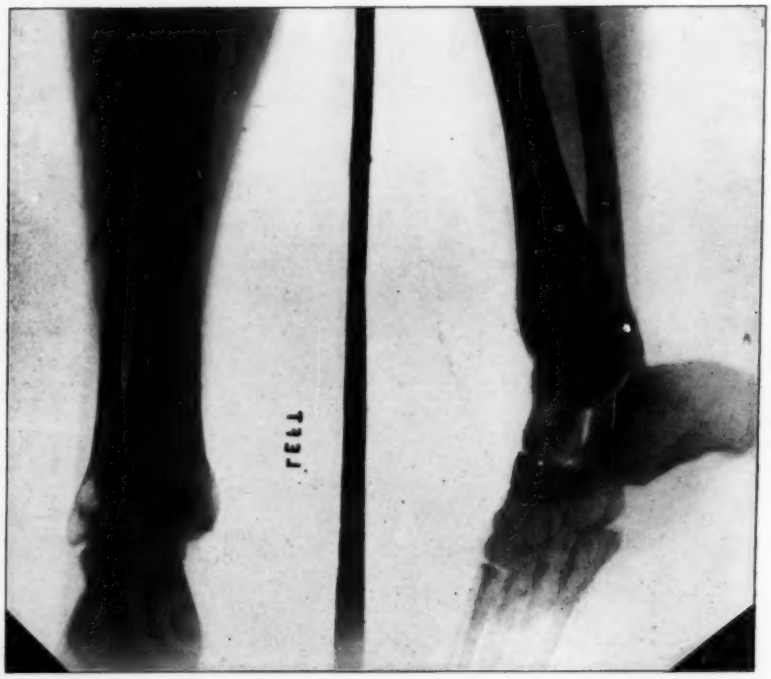

FIGURE 7.—End-result four years after curettage by Barrie.

substance. Partial success only exhibits itself in the metaplasia of the granulation tissue into fibrous structure, forming fibro-cystic processes in bone. Failure or arrest of repair appears to be due to a deficiency in the chemotactic properties of the blood which prevents the formation of sufficient collagen for the further activity of fibroblastic and osteoblastic structure. It is this condition of failure or arrest that gives the pathologic picture of the lesion termed hemorrhagic osteomyelitis. All evidence confirms the inflammatory origin of these processes, which are formed for the purpose of repairing previously destroyed areas in bone.

Etiology: Careful investigation has shown that about 75 per cent. of the solitary lesions trace their cause to bone trauma, recent or remote. Other factors producing localized areas of osteolysis may quite certainly be due to hematogenous infections of low-grade virulency, to endocrinal glandular disturbance or to bone malnutrition. Indeed, this seems to be the only explanation for the appearance of the very rare multiple lesions. Bacteria have never been isolated from the removed tissues in

FIGURE 8.—Hemorrhagic osteomyelitis phalanx. Female, age 18 years. End-result two and one-half years after curettage by S. E. Twinch.

FIGURE 9.—Hemorrhagic osteomyelitis upper end right femur. Female, age 9 years. Before operation.

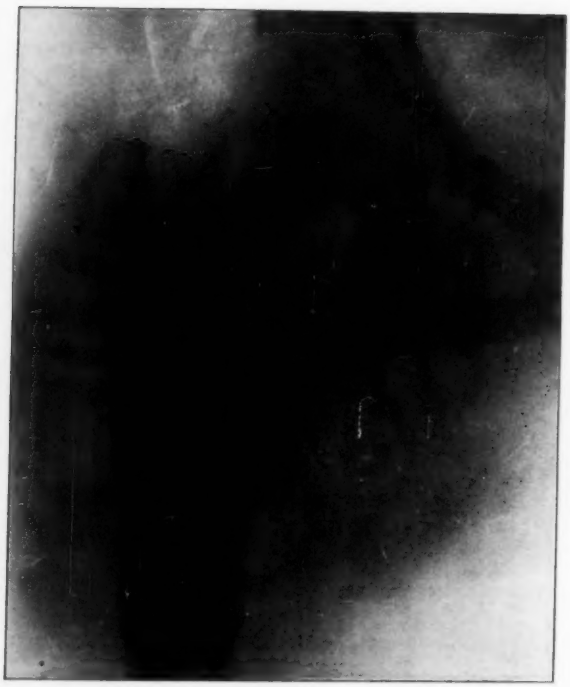

FIGURE 10.—End-result six years after curettage and filling cavity with autogenous bone shavings by Barrie.

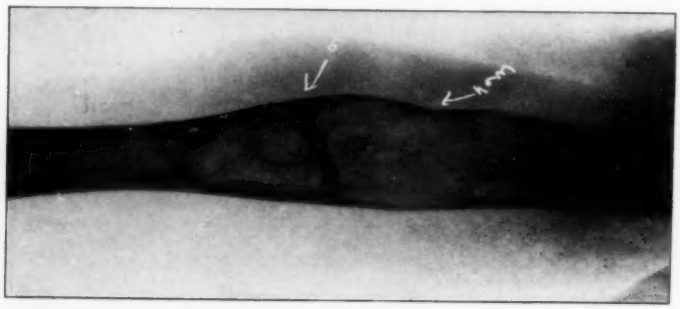

FIGURE 11.—Hemorrhagic osteomyelitis left humerus. Female, age 19 years. Fracture two years ago united and well in six weeks. Re-fracture (pathologic) one week ago. Old and recent fractures noted in picture. Curettage and fillings with Mosetig-Moorhof paste by M. Rehling.

any of the processes. In our experience the solitary lesions have been found at all ages, more frequently, however, during the first and second decades of life. In neither sex are the lesions predominant. Their duration may be months or years.

FIGURE 12.—X-ray taken three months after operation.

FIGURE 13.—X-ray of Rehling's case two years after curettage and bone filling.

The lower extremities have been the site of election in the proportion of three to one. The femur has been most frequently involved of all bones, the upper and lower ends being equally affected; next in order have been the tibia, fibula, radius, humerus, etc.

Symptoms: The symptoms are usually mild unless the lesion has been long-standing and is quite large. Symptoms also depend, in some degree, upon the location of the focus. Lesions in the lower extremity practically always cause limping. Where the process is found near a joint, some limitation of motion in that joint is always present.

The sense of pain is never constant. In the smaller lesions it is apt to be slight, and may be absent until pressure over the site is exerted. Pressure always elicits tenderness and pain. All signs of acute inflammation are lacking.

Pathology: The gross pathology exhibits a dominant picture of highly vascular granulation tissue that composes the mass filling the bone

FIGURE 14.—Hemorrhagic osteomyelitis upper end right femur. Male, age 6 years. Before operation.

cavity. There may be observed within the lesion localized fibrous metaplastic areas. There are also frequently present numerous scattered hyaline bodies in and around the hemorrhagic mass. The microscopic picture is definitely heterogenous. It duplicates in all respects the histopathology of granulation tissue. In some sections the scavenger giant cells are very numerous, in others few or none are found. No uniformity, however, is maintained in their distribution.

Invasion, as understood to pertain to malignancy, is not observed. There are altogether absent the essential features of sarcomatous structure in which the cells of origin reproduce their kind and go on to the formation of true blastomata. The potentialities for tumor formation in the regenerative mass do not seem to be any greater than may occur in other inflammatory tissues. It is all-important to state, and the fact cannot be too strongly stressed, that true tumor giant cells are never found in these processes.

Diagnosis: A pre-operative definite diagnosis is impossible without the aid of the x-ray. The history and clinical picture in these cases simulates many other pathologic conditions of a chronic character affecting the bone.

Lesions have been personally observed in 42 cases, as early as 18 months of life and up to 63 years.

FIGURE 15.—End-result eight years after curettage by Barrie.

The area of osteolysis, exhibited by the x-ray, usually shows a clear-cut rounded or oval spot in the cortex. When the lesion is large this rounded or oval clear-cut appearance may be less sharply defined. Expansion is observed without breaking through the periosteum. Any chronic lesion in which the periosteum has been broken through should be regarded with suspicion as to malignancy, unless it is known to be definitely suppurative.

In our experience, in no instance has a hemorrhagic osteomyelitis penetrated through the cartilaginous structure separating the epiphysis from the diaphysis in children.

In reaching pre-operative diagnostic conclusions we are aided by the chronicity of the lesion, its lack of severe symptoms, the greater frequency of its appearance during the first two decades of life, its clear-cut and non-invasive outline in the x-ray picture, and its non-penetration through epiphyseal cartilage. The lesion is more frequently observed near the ends of the long bones. It may, however, occur in any portion of the shaft.

FIGURE 16.—Hemorrhagic osteomyelitis upper end humerus. Female, age 20 years. X-ray after curettage and graft insert by H. L. Taylor.

FIGURE 17.—Photo showing motion in shoulder-joint three years after operation.

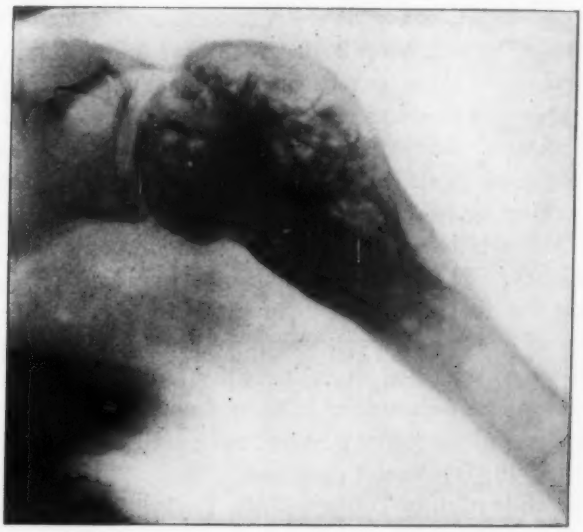

FIGURE 18.—End-result four and one-half years after operation.

The gross appearance of the lesion during operative interference is typical of exuberant hemorrhagic granulations, and finally the microscopic picture, exhibiting no evidence of autonomous growth, is conclusive in ruling out blastomata.

Differential Diagnosis: Differential diagnoses from acute inflammatory infections in bone and highly malignant processes are easily arrived at by a correlation of the clinical picture and x-ray findings.

The localized chronic bone abscess, true bone cyst, myxoma, or early slow-growing fibro-sarcoma, may require, in addition to the clinical and x-ray findings, the gross pathology observed at operation to establish a definite diagnosis. The picture of a highly vascular granulation tissue mass appearing in an area of spongy bone is almost pathognomonic of a hemorrhagic osteomyelitis, but must not be regarded as positive.

The writer has observed one case in which the gross pathology of the lesion simulated a hemorrhagic osteomyelitis. In this patient, however, the clinical history and examination with x-ray findings, independent of the gross pathology, fully corroborated the picture of a highly malignant neoplasm. This was further confirmed by a microscopic picture of definite cellular riot and true tumor giant-cell content.

Treatment: Treatment consists in removing all exuberant granula-

tions that fill the destroyed bone area and thoroughly curetting the cavity wall. Stimulation for final reproduction of normal bone tissue seems to be aided by swabbing with tincture of iodine. In cases where severe hemorrhage follows curettage, firm packing may be necessary for forty-eight hours to control it, before final closure of the operative wound is attempted. Large cavities are aided in the progress of repair by filling with bone graft, chips, shavings, or the use of the Mosetig-Moorhof *plombierung.*

Up to the present time these simple operative measures have proven quite satisfactory. The use of radium or x-ray has the disadvantage of preventing the visible inspection of tissue in non-operative cases, or if the lesions are opened for such treatment, immediate closure is impossible. In all cases operated upon, primary healing has occurred. No recurrences have been observed. The end-results in the patients who have been successfully followed have been excellent. The illustrations show the end-results in some of the cases.

I am under obligation to Doctors H. L. Taylor, M. Rehling, and S. A. Twinch for the privilege of presenting their cases.

DISCUSSION OF DR. BARRIE'S PAPER.

DR. E. W. RYERSON, Chicago: The importance of such work as this of Dr. Barrie is, of course, self-evident. It is of the utmost interest and importance for us to be able to differentiate these various bone—I do not know whether to call them growths or not—appearances. Apparently these conditions are becoming more frequent. We see more cases every year where cavities or areas of osteoporosis exist in the bone. All of these, in my opinion, should be submitted to immediate operation, and then the unfortunate clinician is apt to be up against it. Not long ago I saw a young medical student from a city not far from Chicago, with pain in his shoulder. He was seen by some excellent orthopaedic men who thought a subdeltoid bursitis existed. When he came to Chicago there was a picture exactly similar to one of these pictures we have seen this morning. It seemed to me that if we could show this was a hemorrhagic arthritis it would be of great benefit to the young man. Consequently the shoulder was opened, and a large amount of tissue, corresponding microscopically to what Dr. Barrie found, was removed. A diagnosis of small round-cell sarcoma of a highly malignant character was immediately returned. I asked our leading surgeon to see the case and he considered from the microscopic sections and from the history that it was a giant-cell tumor. The entire area had been carefully cleaned out and what appeared to be the lining membrane removed, and the cavity filled with iodin. He went back to the place where he was studying and I did not see him for three or four months. When he came back the upper end of the humerus was as large as my fist. It looked like a rapidly growing giant-cell tumor, if such things exist. I was not willing to take the responsibility and asked him to go to see Bloodgood at Baltimore. Bloodgood telegraphed me that it was a giant-cell affair. Where is the ordinary hard-working orthopaedic man who does not know much pathology

going to get off? I do not know what Dr. Bloodgood has finally done for the man. I have had a dozen cases in the last few years where these simple shaft affairs occurred. Some of them looked exactly like new growths of the malignant type. I am beginning to be in favor of a radical removal, not by amputation, but by the removal of as much of this tissue and the surrounding areas as possible, and then making a careful pathologic investigation. I have not yet seen what I could absolutely assure myself was an hemorrhagic osteomyelitis. In all of these cases the differentiation from osteitis fibrosa is very difficult.

The etiology is not at all clear to me from Dr. Barrie's investigation. It is difficult to believe that a simple trauma to bone could produce the same condition in the bone as some low-grade infection. It is not altogether clear as to where this infection comes from. I think the whole subject is worthy of investigation because it means the saving of limbs in many cases and the saving of lives in many others. The pathologists are apparently not well informed on hemorrhagic osteomyelitis. Some have not heard of it. When the confusion is as great as it is among the various pathologists whom I happen to employ to make diagnoses for me, I certainly do not feel that any conservative measures should be employed in these doubtful cases.

Dr. Reginald Sayre, New York: I feel very much as Dr. Ryerson does. I am not certain when I see one of these cases just what it is. The first one I encountered was some six or seven years ago. This girl struck her knee and thought she had simply bruised it. After a short time it became very tender. She was running down hill, and the x-ray showed very much the same picture as Dr. Barrie has shown in the upper end of the tibia. I scooped out this cavity and the pathologist said it was a spindle-cell sarcoma. Dr. Bissell put some radium in the cavity. It looked just perfectly lifeless. He put the radium in again and nothing happened. One day the house surgeon stuffed the cavity full of iodoform gauze. I had carefully refrained from putting in anything but plain gauze while the radium was being inserted. When he put in the iodoform gauze the cavity cleared up and the girl got better. Dr. Barrie looked at the x-ray and said the pathologist did not know what he was talking about; that it was one of his hemorrhagic osteomyelitis cases. Dr. Bissell felt his radium cured her and the house surgeon thought the iodoform did it. I was of a quite open mind.

A few years ago another patient came in with a swelling on the knee from a bump on the walk. The x-ray showed the typical appearance of those cases Dr. Barrie showed. I looked at the case and said it was an hemorrhagic osteomyelitis. The x-ray man said it was malignant and should have x-ray treatments. It was subjected to x-ray treatment and it was apparently like dissolving a cake of ice in July. The cortical outline was dissolving and it looked as though it would press through the skin and he advised amputation. I advised scooping out the diseased portion. There was an uneventful healing and the man is walking about today with a good limb.

I have had four or five cases where I did not operate and had good results. There was one small boy with a cyst in the upper end of the femur, whom I presented some years ago at the section of the Academy of Medicine. We treated him with a hip splint. Last year his mother showed me a clipping from a paper saying he had won a foot race in high school. The x-ray shows a gradual change of the cyst into a perfectly normal leg.

Last December a child was sent to me who had symptoms of hip disease. The x-ray showed a cyst of this femur. I treated him this way. A short time ago he came back with a fracture through the cyst. While in the hospital an

x-ray picture was taken. To my great surprise this cyst in the last month has filled out with bone. This brought to my mind the possbility of some of these cyst cases being treated by puncture so as to revivify them. What I presume happened was that the fracture allowed new blood to flow in, just as after cutting the edges of an ulcer of the shin the ulcer will heal. Within two months' time this cyst has completely changed its appearance and the picture of the leg looks like these pictures of operated cysts which Dr. Barrie has shown.

Dr. Sidney H. Cone, Baltimore: I want to say a word to put clearly before you a number of the conflicts which come up between laboratory men and surgeons. During the last two years there has been a great deal of work done in bone and joint conditions in the anatomical and pathological laboratory, particularly by Jordan of the University of Virginia, and Bast of Wisconsin, distinguishing the particular kind of cells found in bone and which will help explain such conditions as Dr. Barrie has described. I feel that inasmuch as we also have difficulty in a few conditions in pathology in its relation to general surgery there are some things which cannot be cleared at once. There is work going on now which will clear up some of the pathology of these hemorrhagic osteomyelitides, particularly in reference to the giant cells found therein.

Dr. S. Fosdick Jones, Denver: I have been particularly interested in this paper of Dr. Barrie, because I believe it is just the type of paper from which we receive a great deal of valuable information. It is difficult at times, even with the best of skiagraphic plates, to arrive at a definite diagnosis of these rarer forms of bone lesions, and the pathological examination is, to my mind, most essential in differentiating and arriving at an accurate diagnosis when these more obscure bone diseases present themselves. For example, in cases of Brodie's abscess, which was recently so well described by Dr. MacWilliams of New York, the skiagraphs of Dr. Barrie's case might well suggest such a condition.

In considering the differential diagnosis of bone lesions viewed from the standpoint of radiography alone, the following two cases will serve to illustrate some of the difficulties which one may encounter.

Some years ago a railroad clerk came under my observation, giving a history of injury to the shoulder from being thrown violently against the side of a postal railroad car. The clinical examination suggested at once the diagnosis of a typical case of subdeltoid bursitis. The first x-ray taken at the time of the examination was negative, and no bony lesion was seen. Immobilization in the Codman abduction splint at first, for a period of two weeks, gave great relief from the acute and painful symptoms. After removal of the splint, three weeks after the injury, the pain returned and a second x-ray was taken which again showed no bone involvement. The abduction splint was continued for another three weeks, but the local pain over the deltoid bursa continued and a slight swelling appeared in the region of the acromion process. A third skiagraph taken about nine weeks after the injury clearly demonstrated an osteal sarcoma, requiring a radical operation.

The second case was that of a girl of seventeen years who was sent to me for a suspected tuberculosis of the knee-joint, in which the x-ray was negative at the time of the first examination. This case has been previously reported by me before this Association. Aspiration of the joint showed a bloody fluid, with no pus, and upon opening the knee-joint, a definite osteal sarcoma involving the lower end of the femur and condyles was present. A mid-thigh

amputation was performed, but ten months later the patient died of metastasis involving both lungs and pleura.

Osteomyelitis will not infrequently give the same picture by x-ray that is seen in early cases of osteitis fibrosa cystica, or in sclerosing non-suppurative osteomyelitis, and early sarcoma is difficult to demonstrate from early bone rarefactions due to some forms of benign bone diseases. Early bone sarcoma and early bone tuberculosis are not infrequently difficult to diagnose from a radiographic view.

DR. GEORGE BARRIE, New York City: I wish to thank the gentlemen who discussed the paper.

STUDIES ON EXPERIMENTAL RICKETS.*

BY P. G. SHIPLEY, M.D., BALTIMORE, MD.

RICKETS has become so familiar in hospitals and dispensaries that in many cases no attention is paid to the disease. The spontaneous recovery of many of the patients has induced a *laissez-faire* policy in its treatment on the part of many physicians.

For the past forty years sporadic attempts have been made to reproduce rickets in laboratory animals by means of the various agents which have been suspected of causing the disease. Some investigators have tried to reproduce it by extirpation of various endocrine glands. Others have tried keeping their animals under bad hygienic conditions, or infecting them with micro-organisms. Perhaps, however, the greatest number have attempted to reproduce rickets by feeding their animals on diets which were in one way or another unsatisfactory. The lack of uniformity in their results is easily explainable in the light of our present knowledge of nutrition. It has only very recently become possible to analyze a diet with sufficient accuracy to know how and to what degree it deviates from an optimal standard. For example, an animal which is fed on starch and horse meat is, as it was thought fifteen years ago, receiving a diet which is low in calcium, but we know now that such a diet is also deficient in fat-soluble A and water-soluble B, and is relatively high in phosphates. Therefore, attempts in the past to produce rickets by the diet, although they were successful in some cases, have been fruitless as far as discovering the cause of the disease is concerned.

Fifteen years ago we were taught that the daily food must contain protein, fat, carbohydrate, and the ions Ca, Na, K, Mg, Cl, Fe, S, P, and I. The latter substances, with the exception of sulphur, which had to be taken in the form of cystin, could be utilized by the body as inorganic salts. We know today that there is a considerable variation in the nutritive value of different proteins. It is generally accepted, moreover, that there are certain other substances which must be present in the food if the organism is to maintain health, growth, and function. These are the so-called vitamins or accessory food substances—fat-soluble A, water-

*Read at the meeting of the American Orthopedic Association, held at Washington, D. C., May 1-3, 1922.

soluble B, and water-soluble C. It is generally conceded that the absence of these substances from the diet is the cause of certain syndromes which have received the name "deficiency diseases." Xerophthalmia results from a deficiency of the fat-soluble A, polyneuritis from a lack of water-soluble B, and scurvy appears as the result of insufficient intake of the water-soluble C. These are the so-called "deficiency diseases," and many investigators have been disposed to add others to the list—pellagra, mucous colitis, chronic intestinal indigestion, intestinal infantilism, and rickets. Rickets is not a deficiency disease in this restricted sense. It is a condition which results from faulty metabolism,—usually, but possibly not always,—caused by a faulty diet.

We have chosen the rat as an experimental animal because of its omnivorous habits, the ease with which a large colony may be maintained, its short span of life, and period of gestation and lactation. All of our experiments have been carefully controlled as regards hygiene, illumination, and exercise.

It is necessary to stop a moment here to discuss rickets as it occurs in children. In the first place, we must appreciate the fact that while the physical pathological manifestations of rickets are largely confined to the skeleton, the disease involves the whole organism. There can be no other interpretation of the loss of muscle tone, the profuse head sweats, the gastro-intestinal disorders, and the apathy or fretfulness of the rachitic child. The pathology of the bone I shall not discuss here, but the pathology of the blood is not so well recognized, and deserves attention. Howland and Kramer found that the calcium in the blood serum of the children averages 9-11 milligrams per hundred cc.; the phosphate of the serum averages 4-6 milligrams per hundred cc. Children with rickets as it is ordinarily seen show little if any reduction from the amount of calcium in the blood, but the phosphate, on the contrary, may be reduced as low as 1 milligram per 100 cc. Children may be seen with rickets, however, whose blood serum shows a marked reduction in the serum calcium, the serum phosphate remaining at or about the normal level. If the serum calcium of these children is below 5 milligrams per 100 cc., the rickets is complicated by manifest tetany. We say that latent tetany is present if actual manifestations of tetany are not found in a rachitic child with a low serum calcium. Healing of rickets is accompanied by the restoration, on the one hand, of the normal phosphate level; on the other, of the normal calcium content of the serum. Now, when rats are fed on diets of purified foodstuffs it is possible, when an uncharacterized organic substance which is contained in certain fats

is insufficiently supplied, to induce rachitic changes in the skeleton in either one of two ways. The diet may be low in phosphorus but high in calcium, or may contain an approximately normal amount of phosphorus and be low in calcium. In other words, there is a level on either side of a normal calcium-phosphate balance at which an abnormal calcium-phosphate ratio of the diet may result in rachitic changes in the bones. In the rat, then, there are two sorts of rickets, one of which results from a diet, *caeteris paribus,* low in phosphorus; one which follows the administration of a diet, *caeteris paribus,* low in calcium. It would seem as if the same thing might be true of children. Normal growth of bone depends on the maintenance of a normal ratio between the two ions,—not on the absolute amount of either in the food. The fact that a perfectly normal bone may be produced on diets which are low either in calcium or phosphorus, providing that the level of the other ion is proportionately depressed, shows that the rachitic lesion is really dependent on the ratio of calcium to phosphorus. There is an optimal level, however, for both ions, and when the balance in the diet is maintained at this point the optimal growth of the animal is assured, provided all other factors of a complete diet are sufficiently supplied. Below this point the salt content of the food may become to some extent a limiting factor as far as growth is concerned.

The optimal amount of calcium which the diet can furnish for growth, maintenance, and function in the rat has been shown to be 641 milligrams per 100 grams of ration, all other factors of the diet being satisfactory. The amount of phosphate has not been so well worked out, but it is about 493.6 milligrams per 100 grams of food. A diet containing 832 milligrams of calcium and 305 milligrams of phosphate produces a lesion which exactly corresponds to the severest form of rickets seen in children. Such an animal will have 10 milligrams of serum calcium per 100 cc., which is the same that a normal rat would show. The blood phosphate for a rachitic animal of this, the low phosphate, type, will be 2.5–3 milligrams per 100 cc.; that of a normal rat will be 8 milligrams per 100 cc. If now an animal is fed on a diet in which the calcium is reduced to 52 milligrams per 100 grams of ration, the phosphorus remaining at 364 milligrams, a lesion also results which presents all the essential characteristics of rickets. The blood of such an animal will contain ca. 4.5 milligrams of calcium and 8–9 milligrams of phosphorus.

The rôle of the fats in rickets. In May of 1921 we published an article which showed that a deficiency of fat-soluble A does not produce rickets, providing the required salt balance is maintained in the food. This has

been since confirmed by numerous investigators. A deficiency in this vitamin is followed by a cessation of growth and a condition of osteoporosis develops. There is, however, a substance present in cod-liver oil, and to some extent in butter fat, which enables an animal to compensate for a faulty calcium-phosphate ratio in the food. This substance is not the same as fat-soluble A. This uncharacterized organic substance is present, according to Zucker, in the unsaponifiable fraction of cod-liver oil. It is present in butter fat and coconut oil, as well as in cod-liver oil, but to a much less extent. Thirty per cent. of butter fat is not the equivalent of 2 per cent. of the diet in cod-liver oil, which will prevent the development of rickets on a rickets-producing diet, and in five days will usually cause visible signs of healing to appear in the bones of a rachitic rat. It will cause healing of the low calcium, as well as of low phosphate rickets. In the low phosphate form of rickets the administration of 2 per cent. of cod liver oil for fifteen days causes the phosphate in the serum to rise from 3 milligrams to 5 milligrams per 100 cc. Howland and Kramer, who have made the studies of the blood which I have quoted, have shown that exactly analogous changes occur in the blood of children under analogous conditions.

Another influence which enables the organism to compensate for unfavorable calcium-phosphate ratios is light—from the sun or the mercury vapor lamp. Huldschinsky was able to demonstrate healing in the bones of rachitic children after radiation with the mercury vapor lamp, and we have found that radiation with sunlight, the mercury vapor lamp, or the Fe-Cr, or Cd arcs, prevents the development of rickets in rats although they are maintained on diets which would cause rickets to develop without fail without the influence of radiation. Such radiation will induce healing in rachitic animals without change in the diet, and causes much the same changes to occur in the salts of the blood serum which follow cod-liver oil therapy. Radiated animals which have been treated with the light of the Cd arc under the same conditions as those which obtained in treating others with the Fe-Cr arc and the mercury vapor lamp, show more advanced healing than the other groups. Filtering the light through window glass removes the protective rays. These facts would make it seem as though the beneficial rays were of the shorter lengths of ultraviolet. From these facts it will be seen that consideration of natural illumination must in the future modify the dietary of miners, convicts, and those who from necessity or ignorance are deprived of light. Individuals who are exposed to full daylight can get on normally with the diet which in the absence of radiation would be

extremely defective. Light, though it protects against and cures rickets, has no demonstrable influence on the appearance of xerophthalmia.

The last consideration which modifies the results of a rickets-producing diet is starvation. Starvation will precipitate in three days an extraordinary degree of healing in a rachitic animal and this healing is accompanied by a marked rise in the blood phosphate. It might be supposed that this might be the result of the restoration of a normal calcium-phosphate balance when the body is left to draw its supplies of these ions from its own tissues. This is, however, not the case. The phosphate of the blood rises from the rachitic level of 3, to 12 mgs. per 100 cc., which is double the amount of the normal blood phosphate. This may be the result of tissue destruction and the release of phosphate from disintegrated muscle tissue.

To sum up, (1) rickets is a disease of metabolism usually due to faulty food. 2. It may be produced in rats by certain diets containing an improper balance between calcium and phosphorus, when an uncharacterized substance associated with certain fats is absent or deficiently supplied. 3. There are two sorts of rickets in rats, one a low calcium type, produced by diets relatively low in calcium, but containing an approximately normal amount of phosphorus, other things being equal, and second, a low phosphate type, produced by diets deficient in phosphorus, with a normal or high calcium content. 4. Some uncharacterized organic substance, which is present in abundance in cod-liver oil, enables the organism to compensate for a defective calcium-phosphate ratio in the food. 5. Exposure to sunlight or to the rays of the mercury vapor quartz lamp will do the same thing. 6. Either of these factors will induce healing in the bones of rachitic animals. 7. Starvation also will induce healing.

These investigations so far leave a great many questions still unsettled. Some of them we are in a position to answer; others await further study.

DISCUSSION OF DR. SHIPLEY'S PAPER.

Dr. R. B. Osgood, Boston: The paper this morning by our distinguished guest, Dr. Jansen, and this most interesting and extremely stimulating paper by Dr. Shipley started so many thoughts that I hardly know where to begin to comment on the work. This work that Dr. Shipley has brought out gives us some of the causes of this disturbance and shows us how treatment should be administered. As he says, the work has just begun. Starting with the

theory that there is a nutritional deficiency either in quantity or in the proper ratio of calcium intake, we must at once think of other diseases besides rickets, the etiology of which these investigations may partially solve. Possibly we still do not know whether there is such a disease as that called adolescent rickets. Dr. Freiberg says positively there is. His experiments seem to show that adolescent rickets is amenable to the same kind of treatment —I think he said cod liver oil—to which this experimental rickets is amenable. Then we have osteomalacia, a deficiency disease or a hunger disease, as the Germans suggest. This seems to be very common as a result of the war. Then we do not know how far we shall go toward solving the problem of osteitis fibrosa cystica or how far toward solving osteitis deformans or perhaps even Dr. Barrie's hemorrhagic osteomyelitis. There are suggested many problems which we shall ask Dr. Shipley to investigate in the next hundred years in connection with rickets.

I do not know how many of you have seen the book written by Mr. McCann. He recites the history of a ship's crew who all came down with what was called beriberi. A diet rich in vitamins was administered and all these so-called beriberi cases got well.

Dr. Jansen's paper is most stimulating as representing an almost philosophical approach to the problem of etiology of rickets and the bearing of heredity.

The work of Dr. Percy Howe of Boston has interested me greatly in relation to the possible infectious etiology. He has considered pyorrhoea as a deficiency disease rather than an infection. He has carried out some experimental work in which he has fed guinea-pigs a certain diet, following which they have exhibited various bone and joint disturbances which seem to resemble the changes we have associated exclusively with the infectious type. Then by simply changing the diet, the pigs become perfectly free from these joint symptoms.

All this subject is, of course, too wide for anybody to discuss. I wish to thank Prof. Jansen and Dr. Shipley most heartily for their papers.

Dr. Frank E. Peckham, Providence, R. I.: This paper is very important to the orthopaedic man. Children are being brought in increasing numbers for orthopaedic conditions which seem to be directly due to faulty metabolism. Probably it is the calcium salts which are at fault, as Dr. Shipley has brought out. In treating these cases, that certainly should be taken into account. For instance, it was only within a few days that a slightly knock-kneed and flat-footed little fellow, dragging one leg, was brought into my office. The physician who referred him to me had first referred him to a neurologist. It was simply a case where the calcium metabolism was at fault. There was the knock-knee, flat-foot, and dragging leg. The treatment of this may be mechanical to a certain degree, but it should be largely a dietetic treatment.

This study which Dr. Shipley has applied to rickets is also applicable to other deficiency diseases. There are lots of these children and they seem to be increasing in numbers, so it is brought to one's attention that something is radically wrong with the nutrition. I do not know who is to blame for it, but that element has to be taken into account. Another very important thing is that in these children the resistance to disease is lowered. I may be wrong about the statistics, but as I understand it there are about a half million children under ten years dying every year in our country because they have not the resistance to put up against the diseases which attack them. Now this lessened resistance in young life is due to some factor, and the points brought

to our attention by Dr. Shipley are of great importance. I want to thank Dr. Shipley personally.

DR. PAUL SHIPLEY, Baltimore (closing the discussion): It may be that I have perhaps unintentionally overstated the dietary side of disease in childhood. In considering diet in relation to disease I should like to say that we have to remember that, as Dr. Jansen said to you a few minutes ago, there are many other agents which aid in the production of illness which apparently is caused and remedied by changing the diet of the child. Col. McCarrison in India has shown—and the point should be emphasized—that faulty nutrition may, by lowering the resistance of the organism to invading bacteria or to other factors of which we at present know nothing, contribute to many diseases which we are accustomed to consider of parasitic origin. It would, however, be a grave error to insist that, because the manifestations of these conditions appear coincidentally with the administration of a bad diet and are alleviated or cured by a good one, the conditions are the result of a bad diet alone. It is time that a warning should be uttered against the rising tendency to attribute disease after disease to nutritional faults. "Avitaminosis" is becoming a fad and is forming a base for the operations of quacks, nostrum venders, and misguided enthusiasts. Dr. Osgood has just now mentioned Riggs's disease as a pathology which has origin in an unfortunate dietary. While pyorrhea certainly follows the ingestion of faulty food, the diet is probably not the sole factor in the production of the disease. The resistance of the tissues, the local and general resistance, is lowered by the faulty diet, and the body is no longer able to take care of the invading organisms, which under normal circumstances it would cope with quite effectively. These organisms are allowed to carry on their work of destruction and produce an apparently inflammatory disease which in many cases is, however, remedied by restoring the diet to the optimal level and so enabling the body to realign its forces against the invading organism. There are probably other factors as well as bacteria which are allowed to work out their harm when the resistance of the organism is impaired by faulty diet. I am quite certain that the whole story of scurvy is not yet told. I am equally certain that we are not as well informed concerning beriberi as we might be. It is equally possible that there are other factors besides nutritional ones operating to produce rickets. All one can say now of rickets is that diets which are faulty in certain respects when fed to animals, are followed by the appearance of the disease. This has held through three years of careful experimental work, but as I mentioned at the beginning, we cannot tell whether these diets behave as chemical reagents, whether they act indirectly on the body as a whole, or whether they lower the resistance of the organism to some morbific agent of which at present we have no conception.

I want to thank the gentlemen who discussed this paper and the members of the American Orthopedic Association in my own name and in the name of those who have collaborated with me.

PATHOLOGY OF TUBERCULOSIS OF JOINTS. A STUDY FROM THE CLINICAL STANDPOINT.*

BY MARK H. ROGERS, M.D., BOSTON, MASS.

THE present conception of the pathology of tuberculosis of a joint, if one judges from the teachings of text-books and from certain pathological studies in the literature, is, briefly, that in a large percentage of cases the original focus is in the bone, generally near or at the ephiphyseal line, and that the involvement of the joint is practically always secondary. In the decade of 1890-1900 there was evidently a great deal of controversy concerning the question of synovial and bone tuberculosis, but the tendency was toward considering the bone as the primary focus and the joint as being involved secondarily. It is not necessary to review the literature preceding this period, except to show there was a definite dispute in regard to pathology.

The conception that primary synovial tuberculosis is anything more than a rarity was evidently disputed and to a large extent discarded after the pathological work done by Nichols in 1898 was published. Nichols, working in the department of Surgical Pathology of the Harvard Medical School, studied a series of 120 cases of tuberculosis of joints, his material being obtained from operations and largely from autopsies. His paper was read before the American Orthopedic Association in 1898 and published in the Transactions of the Association, Vol. xi. This was a very careful piece of work, giving detailed description of many specimens. As a part of his conclusions he states that after an examination of 120 specimens, he is of the opinion that the primary focus is in the bone and that the involvement of the joint is a secondary process.

So that the evidence as published is distinctly that tuberculosis of the joint arises from a focus in the bone and that the joint structure is involved as a secondary infection. The pathology may be briefly described as an invasion of the bone, generally at or near the epiphyseal line, extension towards the joint surface, destruction or absorption of the joint cartilage, on account of the joint lesion underneath the cartilage, and invasion of the capsule.

*Read at the meeting of the American Orthopedic Association, held at Washington, D. C., May 1-3, 1922.

Since that time there has been apparently little work done. Allison, in the *Archives of Surgery*, May, 1921, published a pathological study of the material from his clinic, and he also concludes that the evidence points towards a bone focus as the starting-point. He states that he agrees with Nichols.

From a clinical standpoint this conception of tuberculosis has never been absolutely satisfactory and this has led to a review of the books and references on which the conception is based. It seems to be a clinical fact that a considerable percentage of cases of tuberculosis of joints as seen at the Massachusetts General Hospital clinic could be classified as the synovial type, especially if we select those cases that are seen within the first year of the onset of the symptoms. If these same cases are examined during the third year after the onset then they are generally classified as tuberculosis affecting the bone.

Now this is a possible explanation or at least a suggestion why the pathological studies should point definitely toward a bone lesion. It is very seldom that pathological study is or can be done except on late cases. Certainly Nichols' work was done on old cases and I imagine that the operative material from Allison's clinic represented cases that were of two or three years' duration at least. There is no dispute over the accurate description of the various observers. Nichols' description of his material stands today, but his deductions and conclusions may be disputed.

The purpose of this paper is to present certain clinical evidence that tuberculosis of joints has its origin in the capsule of the joint and that the involvement of bone is usually a secondary process. The evidence to support this conception must necessarily depend on clinical studies of the early stages, because it is very rare to obtain complete material for pathological studies except in very advanced cases. After a study of Nichols' and Allison's work I am not convinced that their conclusions in regard to this one point should be accepted as absolute fact.

A few years ago it was established as a policy at the clinic to perform an arthrotomy on cases of suspected tubercular knees, especially in adults, first for diagnostic purposes, and second, to make an attempt with iodoform-oil to affect the tuberculosis. The result of this work was published by Dr. E. G. Brackett. None of these cases showed any evidence of bone involvement that could be detected by careful x-ray studies or by operative inspection. These same cases were under observation and they later developed definite bone changes and progression of symptoms which led to excision later on. These cases, then, could first

be classified as synovial tuberculosis and later on were typical examples of bony tuberculosis, and if the material were studied four years after the onset of symptoms, would, I believe, coincide with Nichols' and Allison's results.

A recent case of early tuberculosis of the hip in a young adult seems to point strongly to the invasion of the capsule as the beginning of the process. Tuberculosis of the hip beginning in adult life is rather a rare condition in this clinic and we have never seen a case that could be proved tuberculous that did not go on to destruction of bone as an end-result, or, in other words, we are not familiar with strictly synovial tuberculosis.

Mary McF., age 21, had symptoms of intermittent pain and limp of three months' duration. At times, especially after rest in bed, there was no restriction of motion, but there was slight atrophy of the thigh. At times there was limitation of internal rotation and hyper-extension by muscular spasm. The x-rays at month intervals were negative. There was a tubercular family history.

By exclusion, tuberculosis was suspected, and a tuberculin subcutaneous test gave both a temperature and local reaction. The hip-joint was explored by an anterior incision. The capsule was found thickened and reddish in color. Most of the head and neck was inspected and no evidence of any bone involvement found. A piece of capsule was excised for pathological study and showed tuberculosis. Two weeks later an arthrodesis was done, at which time the head was turned out and the cartilage removed and the acetabulum explored. No evidence of bone tuberculosis could be found in the bone.

Of course it may be said that a bone focus was overlooked, but it is rather difficult to imagine that it could be with the exposure that was necessary for a complete arthrodesis. It might possibly be synovial tuberculosis, but it is a perfectly typical story of early tuberculosis and corresponds to our findings in the knee-joint.

It seems to me that we have a good deal of evidence in regard to pathology in the careful studies of x-rays taken in early stages of tuberculosis. A study of the x-rays of the group of knee cases above mentioned shows that there was no evidence of a bone lesion, as a rule, during the first year of the disease. A slight amount of bone atrophy might be present, but this is also present in other chronic infections. Generally the first evidence of any bone involvement was a thinning of the articular cartilage and a slight irregularity of the cartilage outline, probably near the capsular attachment. Then the next step was a definite loss

of cartilage, or erosion of the surface, and only in later stages was there loss of bone substance.

I think the x-ray study of tuberculosis of the spine is a definite method of studying the progress of the pathology and we have enough accumulative evidence from studying certain cases from early symptoms to later results to draw a proper picture. Two cases are cited as examples because both were first examined early in the course of symptoms when it was not possible to make an absolute diagnosis because of lack of any deformity or x-ray evidence of disease. Both cases were adults. They were examined first over two years ago, giving symptoms of recurrent pain and stiffness in the lower lumbar spine, a region which is subject to various possibilities in diagnosis. They were carefully x-rayed at four-month intervals by very competent men, and for the first year a study of the plates failed to show any evidence of a bone lesion. During this period they were treated by fixation, and a probable diagnosis of tuberculosis was made on the history and the physical findings. They both developed abscess, one psoas and the other lumbar. In both cases over a year elapsed before it was possible to show a lesion by x-ray, long after the clinical evidence was very positive, and it took two years to show absolute bone destruction.

In studying many cases of early tuberculosis of the spine the first point noticed is the so-called narrowing of the intervertebral space. There is never any evidence of a bone lesion at first. At this stage when we cannot observe a loss of bone substance we often find evidence of a shadow that is considered to be an abscess. This means, of course, that the process is well advanced. Then later there appears loss of the articular surface, generally of two adjacent vertebrae, and a very late stage is the destruction of the body of the vertebra. I believe this holds true in children as well as in adults, except that sometimes in children the destruction or invasion of bone comes rather rapidly. But the same thing holds true that the joint space and the cartilage are involved first. If the bone were involved first, with our present ability to show complete bone structure, I believe we would have more evidence of bone lesion showing in early cases.

Now for destructive criticism. Certainly in the last decade a good many chronic conditions about a joint were called tuberculosis which have now been differentiated. Hip disease was synonymous with tuberculosis, and any bone cavity within the head or neck of the femur, whether osteomyelitis or bone cyst, was called tuberculosis. Probably many of the definite bone cavities in the lower end of the femur that

used to be considered tuberculosis have been proven to be the result of a coccus infection. If these bone lesions were mostly T. B., then it is easily understood how the present conception of its pathology has progressed and taken root.

Another point which has been suggested earlier in this paper is that most of the pathological work necessarily has been done on end-result or old cases and we all know that there may be found abscess cavities in the bone in such material. But whether it has been proved that these cavities are the original focus or the end-results of extension is not at all clear to me from reading the original papers. I rather doubt that the old contention has been proved.

I think that our best experience in studying the pathology of tuberculosis of joints has been derived from the series of cases of knee-joints, mostly adults, but some children. The same process must take place in one joint as in all joints. That is the natural supposition, so that we can study the problem in the knee, a joint which lends itself to exploratory work.

On opening these joints through the lateral internal incision, the first thing that is noted is that the true capsule is greatly thickened, reddish, and injected. This fact is always demonstrable even in the early cases and those that show absolutely no evidence of involvement of bone as far as can be judged by x-ray studies. In the early stages this may be all that can be observed on inspection of the joint. Of course all that can be seen under this incision is the capsule, the inner half of the condyle, the inner half of the articular surfaces and the upper cul-de-sac. Of course there is usually an increase of free fluid, but this is so in any infection.

The next step in the progress of the disease is the development of a reddish prolongation of the capsule, the pannus that begins to cover the inner surface of the condyle and extends over the articular surface of the femur. The gross pathology at this stage does not differ very much from that of certain other infectious processes, such as due to the gonococcus, except that tuberculosis always seems to be more spongy and reddish.

It is from this material, the capsule and the pannus, if present, that a specimen is taken for microscopic section and tuberculosis can be shown in these sections. In very early cases enough material must be used and careful and complete study must be made of the sections in order not to overlook tubercle formation. Certain reports have come back stating that there was a good deal of round-cell infiltration and

that no other diagnosis but chronic inflammatory tissue could be made, when a more careful search has revealed the definite tubercle formation.

The next step that is noticed in the gross pathology is the extension of the pannus and then the definite thinning and loss of substance of the cartilage beneath the pannus. By this time, if the loss of cartilage is of sufficient extent, it will be possible to detect the same changes in the x-ray, but it is noticeable that the destruction of cartilage is generally more extensive on inspection than appears by x-ray. Then the last stage is the loss of bone substance taking place after the loss of cartilage.

If the study of tuberculosis of the joints from the pathological standpoint is made only on the well-advanced cases, such as come from autopsy material or from late operative work, then it is conceivable how the present idea has held. Nichols' statement that all of his material showed evidence of bone lesions is correct, but of course they all necessarily showed capsular involvement, and the same is true of Allison's studies. But their conclusions drawn can be opened to discussion.

It seems that there is enough clinical evidence to prove that the primary focus is more often in the joint capsule, the same as other infectious processes; that this corresponds to the progress of the disease as studied by x-ray and by early exploratory work done for diagnostic purposes.

DISCUSSION OF DR. ROGERS' PAPER.

Dr. Nathaniel Allison, St. Louis: The paper just read by Dr. Rogers suggests to me that Dr. Rogers has tried to demonstrate by x-ray pictures and more or less by clinical findings certain facts which alone can be settled by the most careful study of pathological material. His argument is concerned with the old discussion as to "which came first, the egg or the chicken." Dr. E. H. Nichols made his report after carefully investigating pathological material. It was my privilege also to take up the study from this same point of view. Neither Dr. Nichols nor I have found any reason to suppose that primary synovial tuberculosis existed in the material which we studied. In my own case, when studying the material at my disposal, I had in mind a careful search for such evidence, but it was not forthcoming.

Dr. Rogers seems to desire to present to us the point of view that clinical observations without operation and without careful pathological study should influence in forming an opinion that there is such a thing as primary synovial tuberculosis. Speaking for Dr. Nichols and for myself, I am sure that I am safe in saying that we both feel that primary synovial tuberculosis may exist, but it is not so important to determine just what structure is the first structure involved in the invasion of a joint by tuberculosis as it is to realize that tuberculosis involving a joint area cannot be parceled out to the various structures which make up the joint. We are dealing in the vast majority of instances with bone tuberculosis—bone tuberculosis and joint tuberculosis—all one and the same picture, and not to be separately considered. It seems to me unwise, and I wish to call the attention of the Association

particularly to this point, to consider joint disease definitely as joint tuberculosis and draw deductions of a clinical nature from this before proper methods have been used to establish firmly a positive diagnosis of tuberculosis.

Dr. W. S. Baer, Baltimore: I am sure we have all been very much interested in Dr. Rogers' paper. It seems to me that the first question you have to answer is, How does tuberculosis get into the joint, into the synovial membrane, into the bone or into the joint tissues? I think Lexer has practically settled the question for us. He has pointed out perfectly well that the epiphyseal portion of the head of the bone is supplied by a series of arteries and these arteries are end arteries, that they end in and about the epiphyseal line. They are called the metaphyseal, the diaphyseal, and epiphyseal end arteries. They remain in the epiphyseal part of the bone until the child no longer needs them. Therefore, at the age of eighteen or twenty these arteries cease to exist. Therefore, in childhood we have end arteries which practically have no connection along their lines and offer a place where the tuberculous bacillus in the blood stream may lodge. This is not the case in the synovial membrane, where there are no end arteries.

So if you grant that tuberculosis is an infection which takes place by the blood stream, this will give you an explanation why tuberculosis originates in and about the epiphyseal line and not in the synovial membrane in children. I think it is possible after traumatism that the synovial membrane may be so damaged that in certain cases tuberculosis may begin in the synovial membrane. For this reason in adult cases I am quite sure that many cases are primarily synovial, although even here there is no doubt that the greater number are bony in origin. I have been doing some little work in the treatment of tuberculosis of the hip and I must confess that I think the status of the treatment of tuberculosis of the hip today is far from satisfactory. Cases of true tuberculosis under the present line of treatment do not recover quickly, nor do they recover entirely. The cases which formerly were our best cases so far as the results are concerned, have turned out to be cases of Perthes' disease and not tuberculosis. We have thought we could get good function in most of our cases of hip tuberculosis, but if you will go over your cases and study them carefully, if they are anything like mine, you will agree with me that this is far from true. I have opened a few extremely early cases of tuberculosis of the hip with the idea of doing an arthrodesis so as to make the circulation of the epiphyseal portion of the head of the bone come in direct contact with the circulation of the acetabular cavity, and thus make the blood stream continuous: in other words, do away with the end arteries. I am not ready to report upon this series of cases as yet, except to say that I am gratified at the early recession of the tubercular symptoms. If we do away with the cartilage and bring the bony surfaces directly in contact, we aid materially in eliminating the tuberculous material just as we do in a resection of the knee-joint for tuberculosis. One thing I want to say is that in the examination of pathological specimens of these early cases of tuberculosis, I found very little inflammation of the synovial membrane. The cartilage on the head was practically normal and when you stripped the cartilage from the head of the bone you found the tuberculosis between the cartilage and the epiphyseal line. If the tuberculosis had come from the synovial membrane you would certainly have had an early destruction of cartilage, but as tuberculosis is mainly an epiphyseal condition, the cartilage is not destroyed until a very late period and is the one thing that prevents an early restitution of the tissue to normalcy.

Dr. R. B. Osgood, Boston: It is stimulating that we have a few good results. One case that seems to be instructive is of a young boy, showing first in the x-ray nothing but an enlargement and squaring of the epiphyses, and a knee-joint that in the x-ray looked exactly like tuberculosis. A family history of tuberculosis and an abscess present in the popliteal space that was probably tuberculous. He was in the Children's Hospital, and later in the Massachusetts General Hospital, running a very mild course, very much like another case of Dr. Lovett's that I have seen recently. He went on for years, never showing any more than a slight erosion on one of the condyles. There was an arc of motion in the knee-joint that was entirely free from any symptoms. He could bear weight without any difficulty or pain. I allowed him to wear a brace, allowing him a few degrees less than his painless arc of motion. I followed him for three years and his symptoms subsided, with 40° to 50° of motion remaining. I then lost him. I saw him this year as a Freshman in Harvard, 18 years old. The leg on the affected side is three-fourths of an inch longer, and the x-ray shows a perfectly normal leg except for the one little area where there was the slight erosion on the femoral condyle. He is well as far as one can tell except that motion is limited to a right angle, and calf and thigh atrophy persist. Weight-bearing is painless. One cannot conceive any very large involvement of bone originally. Is it tuberculosis? I do not know, but it had all the earmarks of tuberculosis. He had an arc of painless motion, a painless abscess, and a negative Wassermann.

Dr. B. H. Whitbeck, New York City: Dr. Baer refers to the discouraging work in the treatment of tuberculosis in the conservative ways. I would like to take exception to that. We realize that in pulmonary tuberculosis recognized in the very earliest stage, if we get those patients to the Adirondacks or to Colorado, the disease is very promptly arrested and in most cases the man returns to his home with a healed process which is practically negative as far as he is concerned. If he stays at home he may die or the process may progress to the extent of destroying the lung, with cavity formation, etc. The condition, I think, is analogous to that in bone tuberculosis, and I feel that tuberculosis of the joint is a constitutional disease and at the earliest moment those children should be placed in the best possible surroundings for the cure of bone and joint tuberculosis. A number of you have been in my hospital at the seashore and have contrasted the appearance of those children with the average clinical case. It has been nothing more than good surroundings, good care, and not so much the orthopaedic treatment. I believe if these cases at the earliest possible moment when the diagnosis is made are placed in the country or at some seashore hospital, the time will come when we shall have a larger number of good functional joints. I am not prepared at present to present the results of the treatment at the hospital, but shall in the future. I believe every effort should be made to treat these cases in the same manner that the medical man treats pulmonary cases.

Dr. W. S. Baer, Baltimore: I fully agree with Dr. Whitbeck that constitutional treatment of these cases is necessary and that these patients should be treated under the best possible conditions for the cure of constitutional disease. I might say that the cases I have been treating have been in the hospital where open-air treatment is given.

The open-air treatment alone will not be sufficient. More radical procedures are necessary.

CERVICAL RIB.

(WITH A REPORT OF 6 CASES, ONE OPERATIVE.)

BY SAMUEL W. BOORSTEIN, M.D., F.A.C.S., NEW YORK CITY.

AMONG the subjects recently brought before the profession, "cervical rib" occupies quite a prominent place. We find, however, very little about it in the orthopaedic literature. In the *Journal of Orthopaedic Surgery* there are only two articles on the subject: one by Henderson,[6] the other by Plummer.[12] It seems that the neurologists and neurological surgeons claim that for their field.

The subject has, however, a great interest for the orthopaedic surgeon, as many cases of shoulder disability, no doubt, are due to cervical ribs. The diagnosis is, therefore, of importance to the orthopaedist. As for treatment—it certainly belongs to him, as bone afflictions should come automatically to him.

Within the last year, the writer has seen in his practice several cases of shoulder disability, which presented very interesting symptoms. On one patient he operated.

The fact that these cases came for complaints requiring orthopaedic skill caused him to feel that other orthopaedic surgeons are similarly consulted for such afflictions. This encouraged the writing of this article.

We will review briefly the pathogenesis and symptomatology of cervical ribs.

One must remember that vertebral changes (and one finds many of them) are frequently associated with variations in the ribs. The changes, of course, are frequent where one type of vertebra merges into the other. Thus we find cervical ribs, rudimentary thoracic ribs, and many varieties of last lumbar. The etiology of this need not be discussed at present. Henderson,[6] Honeij[7] and McWhorter[10] discuss the etiology in detail in their excellent articles.

Direct trauma, due to carrying objects such as a rifle on the shoulder, forceful motions of the arms, or even slight trauma where tension is already present, is often considered as the cause.

Gruber[7] classifies cervical ribs as follows: (1) A slight increase in the costal process, not reaching beyond the transverse process. (2) When

the rib protrudes beyond the transverse process to a certain degree and either terminates in a free end or is attached in some way to the first rib; (3) those ribs which extend well beyond the transverse process and a considerable distance towards the first rib, even reaching the cartilage of the normal first rib—they possess a good body and are often united by a ligament to the first costal cartilage; (4) the rib which is completely developed, articulating with the first costal cartilage and with the sternum.

In reality the size of the rib bears no definite relation to the intensity of the symptoms produced. Some of the large ribs have caused little or no trouble.

Many observers, especially Taylor,[17] reported that many cases present an aponeurotic band which runs forward and downward to an attachment to the first rib. This aponeurotic extension causes the same symptomatology as does a false rib of similar extent. The symptoms are more common on the right side than the left, due to greater use of that limb.

SYMPTOMS.

Honeij[7] is correct in his statement that cervical ribs present two interesting groups of cases. (1) Those that have all the symptoms associated with this condition and yet have no cervical ribs and those that give no symptoms and on examination prove to have cervical ribs. Of course, we have to add the cases that have the symptoms and do show the cervical ribs.

In the majority of cases the symptoms first appear between 20 and 30 years of age. Various reasons are given for the late appearance of symptoms; the ossification of the rib with resulting increased rigidity, which goes on between 15 and 25 years of age; traumatism, exemplified in the carrying of heavy weights in the hand or on the shoulder, which would drag the extremity downward and so increase the tension of the lower nerve roots over the false rib; habitual faulty position, standing with shoulders stooped and carried forward (Case 2), poor muscular development or marked relaxation following a debilitating illness, all of which allow the extremity to sag and increase the tension of nerve roots over rib. (Most of these causes have great significance for the orthopaedist, as he can by preventive measures guard against such occurrence.)

Keen[9] gives an excellent division of symptoms as follows:

1. Local symptoms: tumor, pain or pressure, bruit, etc.
2. Nervous symptoms more frequent than vascular.

3. Vascular symptoms: pulsations, ischaemia, gangrene, edema, thrombosis, and aneurism.

4. Muscular symptoms: wasting, loss of power, easily tired, dysphagia, scoliosis.

We will elaborate slightly on these general principles. On palpating for the tumor at the supraclavicular region one must keep in mind that the subclavian artery rises higher than normal in the neck. It passes above the rib when it is nearly or quite complete, lies in front and slightly below the tip of the less extensive ribs, or lies over the aponeurotic extension, running forward from the tip of the more rudimentary ribs.

The lung apex usually rises higher than normal. The lower roots of the plexus can be felt more distinctly than usual and are more sensitive to pressure, which also aggravates the sensory symptoms already present.

The nerve symptoms are usually neuralgic pains moving down on the same side where the rib is present. Numbness, tingling, and formication are often present. Usually the ulnar nerve or the inner cord is involved though there is no constancy about that. Some cases show analgesia. Ataxia has been described by some observers.

The vascular symptoms may vary from slight coldness to actual gangrene. Pallor, cyanosis present. Edema present. (Case 6.) A difference in radial pulse has been reported.

Of the muscular symptoms—atrophy of certain muscles, the intrinsics of the hands, and of the thenar and hypothenar eminences are those most usually involved. There may be atrophy of the entire arm, but that is due to disuse. Loss of power in the hand grip is noted.

Rare symptoms are: hyperthyroidism and aneurism. Many observers have published cases in which dissociated sensory disturbance suggested syringomyelia. Bassoe[17] has emphasized the fact that true syringomyelia is a not infrequent associate of cervical ribs.

DIFFERENTIAL DIAGNOSIS.

We will discuss only those diseases for which the orthopaedic surgeon is liable to be consulted.

1. Arthritis.—Many cases of neuritis and shoulder disabilities are, of course, due to arthritis. One must keep in mind the muscular spasm, the limitation of motion, and frequent crepitus present in arthritis. The onset of arthritis, of course, is different. Many joints are usually involved.

2. Anterior Poliomyelitis.—Is usually in younger children and the paralysis is extensive. The pain, except at the onset, is absent. No sensory disturbance. The onset (if it occurs in an adult) is sudden. There should be no difficulty in differentiating between them.

3. Erb's Palsy.—Gives a distinct deformity of adduction and inward rotation and dates from birth.

4. Subdeltoid Bursitis.—Gives tenderness in front of the shoulder-joint just over the bursa. Limitation of motion to abduction and outward rotation. No vascular or sensory disturbance. Onset is also sudden.

5. Scoliosis of cervical region should really make one suspicious of cervical rib, as in all cases of scoliosis some abnormality of the vertebra would be present. The x-ray, of course, would show the abnormality, though both conditions may be present.

6. Callus formation from fracture of the first thoracic rib or clavicle. The history of the trauma and the absence of the neuralgic symptoms helps.

7. Occupational neuritis.—Will produce the same neuralgic symptoms, but there will be no vascular disturbance.

8. Transitory torticollis due to some nerve irritation will probably give a distinct history. No vascular disturbance.

9. Exostosis of transverse process would give the same symptoms and the treatment is really the same.

10. Tuberculosis of cervical region should not give much difficulty for orthopaedic surgeons.

11. Neuritis shows marked tenderness along the course of the nerves. The other symptoms are the same as cervical rib.

A cervical rib must be thought of in any case of sensory nerve symptoms along the distribution of the lowest brachial nerves, paralysis of the intrinsic muscles of the hand, vasomotor changes in the hand, and tumor or subclavian pulsations in the region of a cervical rib.

RADIOGRAPHIC FINDINGS.

The x-ray is of great help after a careful neurological examination. Good stereos are necessary.

One must bear in mind that normally the x-ray shows that the transverse processes of the seventh cervical vertebra are shorter than those of the first dorsal vertebra. Sometimes, however, it is difficult to decide.

Dupie and Todd[16] state emphatically that every enlargement of the transverse process of the seventh cervical is really a rib.

TREATMENT.

Radical removal should always be considered if there are no definite contraindications.

Taylor[17] gives the following guides in the prognosis following operations:

1. "The more pronounced and advanced are the symptoms, the less likely is the result to be a complete cure."

2. "The more the nerves have been damaged by the rib, the more are they susceptible to lasting damage from any traumatism at the time of operation."

3. "If operation is delayed until more or less thrombosis has occurred in the arteries of the extremity, then the result must be far from satisfactory."

4. "When a complicating neuritis involving the entire plexus is present it might well be advisable to enforce rest and treatment until the neuritis has largely subsided before removing the rib, since operation during the active stage would undoubtedly cause postoperative aggravation of the pain, and the nerves would be more susceptible to damage in other respects."

METHOD OF OPERATION.*

Operations for the removal of cervical ribs have been classified in three general groups:

1. The "anterior," in which the incision is made along the posterior border of the sterno-mastoid muscle, thus giving exposure of the front of the plexus and the cervical rib.

2. The "lateral," in which the incision is above and parallel to the clavicle, or runs along the anterior border of the trapezius muscle. In either case the exposure permits attack on the rib from the lateral aspect of the neck and plexus.

3. The "posterior," in which a vertical incision is made about 2 to 3 cm. to the side of and parallel to the spinous processes of the cervico-dorsal vertebrae, giving an approach through the trapezius muscle to the posterior aspect of the rib close to the vertebra.

* Dr. A. S. Taylor, with whom I had the privilege of working on some of these cases, and whom I assisted at the operated case, published recently a paper on the surgical aspect of the cervical rib.[17] He has been kind enough to permit me to quote him freely. The details of the operation are, except for a few personal remarks, taken *verbatim* from said article.

There are many objections to each method and some steps of these operations are quite difficult. Taylor[17] has elaborated the best method, which is more simple. The method is as follows:

The incision starts at the posterior edge of the insertion of the sterno-mastoid muscle into the clavicle and passes upward and outward to the border of the trapezius muscle, making an angle of about 45 degrees with the clavicle.

It may slant either above or below this line according to the conformation of the individual neck. This incision lies right in the natural wrinkles of the skin. After healing, it always remains as a fine hair line instead of spreading, after a few months, into a broad, ugly scar as do the skin incisions made in other directions in this part of the neck.

When this incision is carried through the skin and fascia, the transversalis colli vessels are tied and divided, the fat in front of the plexus is mobilized at its outer edge and retracted inward, and then the brachial plexus is exposed.

The cervical fascia is divided along the outer edge of the plexus, which is then separated from its bed posteriorly sufficiently to expose the rib, and is then very gently retracted forward. This rib is usually higher in the neck than one thinks it is, so that care must be exercised not to mistake the posterior end of the first true rib for it. Where the accessory rib is of good size, it is more readily identified, but when it is rudimentary it is often entirely buried in the scalenus medius muscle. In this case it is helpful to locate the prominent carotid tubercle (C VI) and then to feel just below it to identify the rib. (C VII.)

Once the rib is definitely made out, its muscular and ligamentous attachments are divided by sharp dissection so as to leave all periosteum on the rib. Great care must be used to protect the pleura and the subclavian artery.

In several reported cases, periosteum, which has been left *in situ*, has generated new bone and symptoms have recurred.

The last portions of the rib to be freed and removed are the neck and head. These are in the center of the danger zone. The seventh cervical root comes out of its spinal foramen and passes over the neck of the rib at about an angle of 60 to 70 degrees. In the rudimentary ribs the whole thing is apt to be a flat plate of bone extending from the vertebral body outward to, or a little beyond, the tip of the transverse process and having its edges in the vertical transverse plane, so that its upper edge lies just beneath the seventh root at its exit. In the more

fully developed rib, the head and neck are more like the normal and present no sharp edges to the seventh. These anatomical variations may help to explain the frequently observed clinical fact that the small rudimentary ribs often cause more neurological symptoms than do the fully developed ribs.

Just in front of the neck of the rib runs the vertebral artery with its plexus of veins, except in the unusual type where the artery enters the foramen in the seventh instead of the sixth transverse process. It is obvious then that the removal of the neck and head causes the chief hazard to the vessels and nerves.

After the outer portion of the rib has been dissected free from its attachments it is grasped by a small bone forceps and manipulated as convenience dictates while its inner portion is dissected free. Sometimes it is possible to get a clean enucleation of both neck and head, especially when they are held to the vertebra by regular articulations, but frequently, because of troublesome hemorrhage or of firm fibrous or bony union of the head to the vertebral body, one must be satisfied to leave the head of the rib *in situ*. This has seemed to cause no late disturbance. It is important to remove the rib right up to the head because there might otherwise be continuing irritation of the seventh root. This is accomplished with the slender-bladed rongeur.

During all this dissection the plexus must be held slightly forward on a blunt flat retractor with the edges rounded so as to avoid the pressure of any sharp edge on the retracted nerves. The amount of functional loss in the nerves as a result of operation is almost entirely dependent upon the skill, gentleness, and continuing thoughtfulness of the assistant holding the retractor. One must make frequent remissions in this part of the procedure with removal of the retractor to avoid the prolonged compression of the nerves.

Toward the end of the procedure, annoying hemorrhage is apt to result from injury of some of the veins forming a plexus about the vertebral artery. Packing controls this type of bleeding in a few moments. So, if by chance the vertebral artery should be damaged, it would be most unwise to attempt to clamp and ligate *in situ* because of the risk to the plexus in the necessary manipulations. However, it would be easy to expose the vertebral artery near its origin through the anterior inner portion of the wound for ligation. In the same way the inferior thyroid could be ligated if by any chance it should be injured.

In case of ribs which are complete or nearly so, the portion in front of the plexus can be dissected free and removed. The plexus can then be mobilized, gently retracted forward and slightly inward, and then the remainder of the rib removed by lateral approach to the rear of the plexus, as above described.

In the rudimentary type the entire bone may lie within the scalenus medius muscle, which must be split between its bundles until the tip of the rib is located. It is then enucleated as above described. In this type there is frequently, if not always, a strong aponeurotic extension running from the tip and lower margin of the rib forward and downward to the first true rib, or even to the sternum. This aponeurosis, being tense, causes pressure on the nerves as they pass over it. It must be thoroughly released from any attachments that hold it taut.

The rib having been removed and hemostasis secured, the fat is replaced in front of the plexus, and the wound is closed without drainage by means of interrupted and continuous silk sutures which include the skin and fascia. The lips of the wound fall together naturally. After 5 to 7 days the sutures are removed. After a short time the scar is lost among the natural skin wrinkles.

The postoperative disturbances may be due to (1) a bony new formation of the stump, especially if subperiosteal resection is done. (2) Injury to the pleura with emphysema or empyema. (3) Aneurism. (4) Injury to the plexus causing increased paralysis and muscle wasting, and (5) acute neuritis.

The nerve and blood-vessel symptoms, as a rule, gradually abate after resection of the rib, but may persist a year or even longer.

CONCLUSIONS.

1. Many cases coming to the orthopaedic surgeon with shoulder trouble may be due to cervical rib.

2. Cases presenting following symptoms: pain, especially on motion, cyanosis, and atrophy of the limb, and no limitation of motion, should make one suspicious of a cervical rib.

3. The fullness of the supraclavicular fossa, besides the x-ray, should help in the diagnosis.

4. The removal of the rib should be practiced by the orthopaedic surgeon for the same reason that he removes the transverse process of last lumbar.

5. Where symptoms have existed over a long period, and especially where paralysis and atrophy form part of the picture, removal of the rib will stop the progressive increase of the symptoms, but may not result in the entire recovery of what has already been lost. This indicates the necessity for early diagnosis, and the desirability of good stereo-radiographs of the neck in every case of persisting pain or lameness of obscure origin.

6. In all cases of shoulder trouble, x-ray of cervical spine should be taken, since, if the cervical rib may not be the sole cause, it may be a contributory cause by interference with the circulation and nerve supply.

FIG. 1.—Case 1. H. D. Showing the deformity of the spine and prominence of the scapulae.

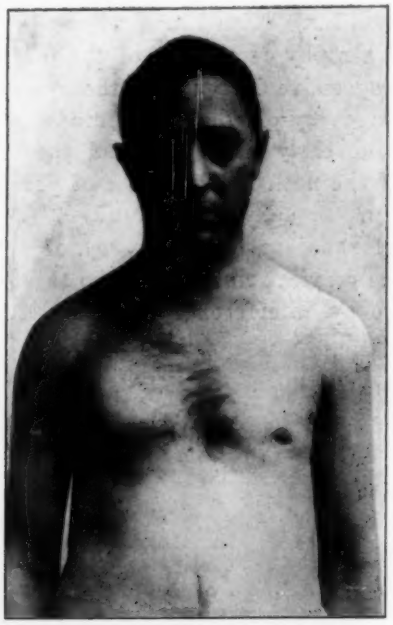

FIG. 2.—Case 1. H. D. Anterior view, showing the fullness of the neck.

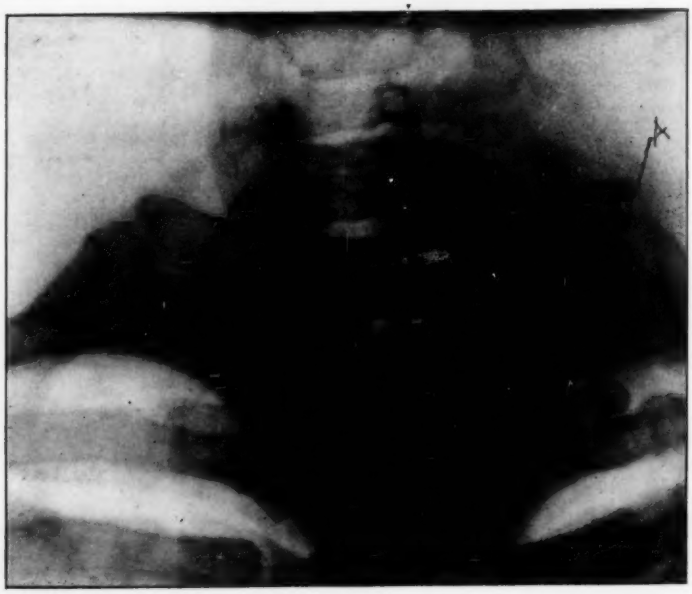

FIG. 3.—Case 1. H. D. X-ray prints of cervical spine, showing the cervical rib at A.

CASE REPORTS.

I am reporting only cases that had symptoms usually found in cervical rib. The diagnosis in every case was made before the x-ray verified the diagnosis. Cases that had cervical ribs but no symptoms, and in which the discovery was made accidentally, are not included, as they are too numerous.

CASE 1.—H. D., male, age 28, came for pain and disability of left shoulder.

The history dates back to age of seven when, after some acute illness, it was noticed that the spine became deformed and that neither shoulder could be used properly. Nothing was done for that, as he lived in a small town in Russia and did not have to do a great deal of work. Upon arrival in this country, he began to work as an operator and found that he could not use his shoulders well and had to give up his occupation.

Physical examination.—Patient is well developed. Angles of the scapulae are markedly prominent, giving him marked kyphosis. (Figs. 1, 2.) There is a fullness of the supraclavicular fossae, left more than right. The subclavian arteries are felt higher on both sides than in normal persons. Patient cannot abduct the arms to more than an angle of 75 degrees with torso. Rotation outward markedly limited. The fingers of both hands are extremely cyanotic and cold when hanging down, left worse than right. On raising the hands, the cyanosis slightly diminishes. The patient has absolutely no pain or sensory disturbance. Motor grip power—35 lbs in each hand. There is an atrophy of ½ inch in the right arm and forearm as compared to the left. Slight atrophy of interossei, thenar and hypothenar eminences of both hands.

X-ray shows distinct cervical ribs on each side. No arthritis present in the shoulders. (Figs. 3, 4.)

Advised operation, which patient refused.

The patient was reëxamined one year later and no change found.

Comment: This case demonstrates distinct orthopaedic disabilities as kyphosis, limitation of motion, and cyanosis, due mainly to cervical ribs. From the limitation of motion one would diagnose the case as ankylosis of shoulder-joints were it not for the interference of circulation and the fullness of the supraclavicular fossae which helped in the diagnosis. There was also absence of pain in the shoulder-joints. The cause in this case is probably some infection which caused adhesions

FIG. 4.—Case 1. H. D. X-ray prints of cervical spine at a different angle, showing the cervical rib at A.

FIG. 5.—Case 2. G. J. Showing the cervical rib at A.

interfering with the motion of the shoulders. The fact that the progress is slow indicates that not all cases lead to severe vascular disturbances.

CASE 2.—G. J., female, age 23. Came in November, 1920, complaining of pain in the left shoulder radiating to the fingers. History dates back one year. No cause could be ascertained.

Physical examination.—Patient is a thin-looking girl. Slight round shoulders. Marked fullness of the left supraclavicular fossa. Both scapulae are prominent posteriorly. Left shoulder presents no limitation of motion, no crepitus. There is distinct atrophy of the left arm (almost one-half inch). The left hand is cyanosed and feels cold. X-ray shows a distinct cervical rib on the left side. (Fig. 5.)

Advised operation but patient refused. She cannot be traced at present.

Comment: The symptoms here were only pain in the shoulder radiating to the fingers and slight interference with the circulation. One might easily have diagnosed it as an arthritis. The atrophy of the arm could easily be explained as due to disuse. The diagnosis was made on account of the fullness of the supraclavicular fossa and cyanosis of the fingers.

CASE 3.—C. R., female, age 23. Complained of pain in the right shoulder dating back a few months. The pain was aggravated on using the shoulder in bringing it forward (flexion forward) while working. No pain at night. Pain ceased altogether after abstaining from work for a few days, but recurred with the work.

Physical examination.—Right shoulder shows distinct crepitus, especially in outward rotation. Fullness of the supraclavicular fossa. Atrophy of the arm. No cyanosis. No sensory disturbance. Before coming to me patient had seen several surgeons and diagnosis of arthritis had been made. My diagnosis was cervical rib.

X-ray showed distinctive cervical ribs on both sides, right larger than left.

Advised removal but patient refused.

January, 1922.—Sent for the patient for reëxamination and obtained the following additional notes: The pain became gradually worse so that she was finally forced to give up her work altogether. Atrophy of the hand increased.

X-ray showed that ribs have increased in size.

Comment: The characteristic pain and the fullness of the supraclavicular fossa established the diagnosis.

CASE 4.—A. S., female, age 36, came to me in May, 1921.

Previous History—negative. Present Illness—dates back three weeks, with pain in the right hand and shoulder. Pain is worse at night, though she has a great deal of pain during the day. Does not complain of coldness or numbness of the fingers.

Physical—general health is rather poor. There is left facial paralysis from infancy. Right hand—fingers slightly cold and cyanosed. Right elbow—motion free, no spasm. Right shoulder—slight crepitus in outward rotation and abduction. Slight spasm in these motions. Tenderness over the deltoid bursa. Some fullness of the supraclavicular fossa. No dullness present. Right shoulder is considerably higher than the left and gives the impression of an old condition. Slight contraction of right sterno-cleido mastoid. Motor grip power—right hand, 30 lbs.; left hand, 40 lbs. No cyanosis present. Diagnosis rested between deltoid bursitis and cervical rib.

X-ray shows distinct enlargement of the transverse process of seventh cervical and suspicion of a facet. The length was about one inch more than on the left.

The patient was seen also by Dr. A. S. Taylor, who agreed with the diagnosis.

Advised removal but patient refused.

CASE 5. R. E., female, age 12. Had high scoliosis since birth and had been treated with jackets, Abbott's jackets, etc., but obtained no relief. X-rays were always negative. For the last year complained of slight numbness in the left hand.

Physical.—Fullness of left supraclavicular fossa, cyanosis of the hand. Left dorsal and cervical scoliosis. X-ray showed distinct cervical rib.

Advised removal but patient refused.

Comment: The disturbance was slight, but the scoliosis was marked.

CASE 6.—Max K., age 22. Physician (this case was also reported by Dr. Taylor in his paper). Came to me in June, 1920, when still a medical student.

Previous History.—Influenza in 1918.

Present Illness.—Dates back to the end of March, 1920, when he

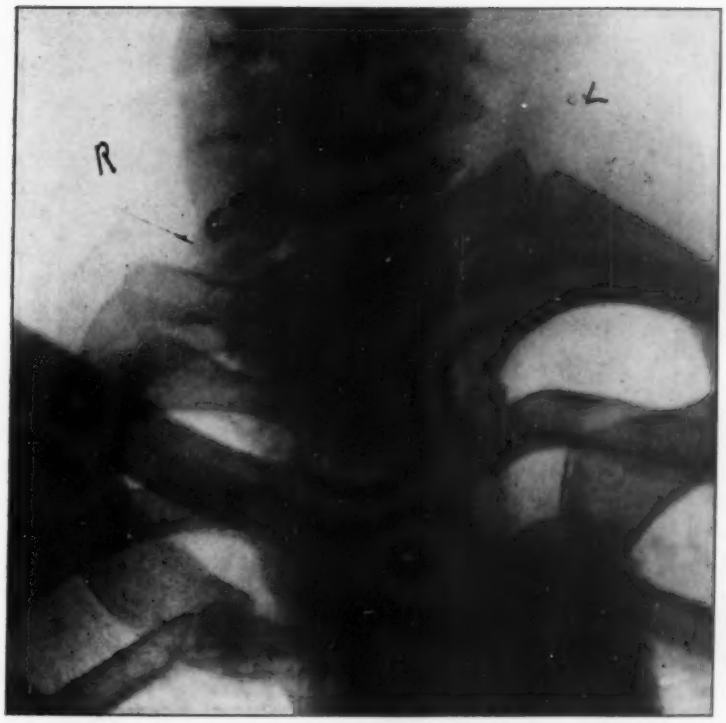

FIG. 6.—Case 6. K. M. Showing the cervical rib on the right side.

noticed that the right upper extremity had become very much larger than the left, that it was often cyanotic, especially in the cold, and that it felt colder both subjectively and objectively than the left. The entire limb often felt very stiff. It tired very quickly under any sustained effort, but otherwise did not seem to have lost strength. Found also some discomfort in writing and excessive use. Numbness in the fingers very often. He had never had real pain. He was examined by five different specialists and diagnosis of mediastinal tumor and aneurism made.

Physical Examination.—Patient is a tall, slender man, of good color and fairly well nourished. General examination shows nothing of interest. The right upper extremity shows an increase in circumference over the left by one and one-half inches in the middle of the arm, one inch in the forearm and one-half inch in the hand. The hand is cyanosed and feels cold. Its superficial veins are twice as large as on the left side. There is distinct crepitus in the right shoulder. No sensory disturbance. Motor power grip—right, 60 lbs.; left, 40 lbs.

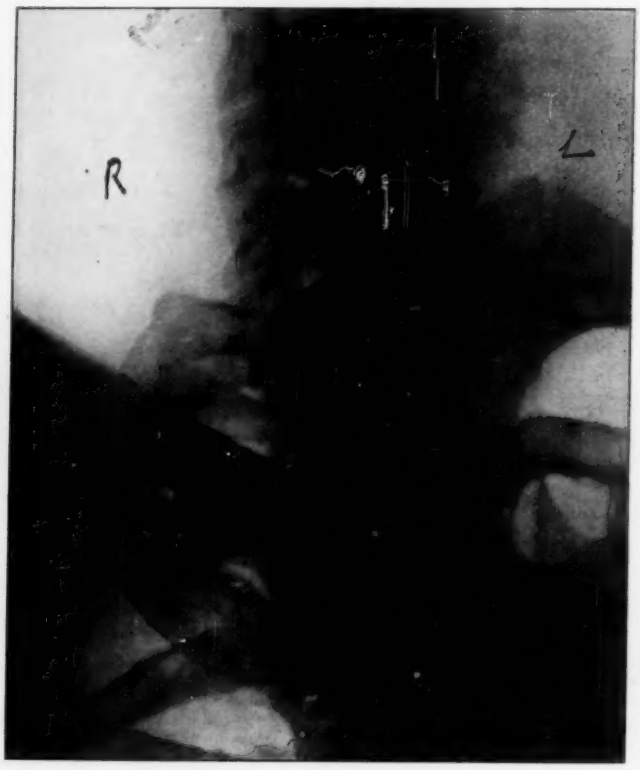

FIG. 7.—Same as Fig. 6, taken at a different angle.

In the right side of the neck there is a distinct bony prominence about on a level with the transverse process of C VII. Just below and in front of this prominence is the subclavian artery, which is well above the level of the clavicle. The cords of the plexus can be felt distinctly above it, and pressure on the lower one over the end of the prominence causes tingling in the inner fingers. There was no inequality in the radial pulses. There was no scoliosis.

The x-ray plate showed enlarged transverse process of C VII, which extended on the right side well beyond that of D I, or C VI, and was quite vertical. (Fig. 6.) As it had no facet, the roentgenologist reported that it was not a cervical rib.

I sent this patient to Dr. Byrne, the neurologist of Fordham Hospital, who agreed that the symptoms pointed toward a cervical rib, though he did not care to commit himself to the diagnosis.

The patient was then examined by Dr. A. S. Taylor, who diagnosed the case definitely as a cervical rib.

Inasmuch as the clinical diagnosis pointed obviously to cervical rib, and the transverse process of C VII was unduly large, it was decided to operate.

Operation on June 18, 1920, by Dr. A. S. Taylor and the writer.

The method described above was followed very carefully.

The rudimentary rib extended about 1-3 inch beyond the posterior tubercle of the transverse process and was a broad plate of bone which extended downward almost to the neck of the first true rib. From its tip and lower border strong fibrous bands stretched forward and downward to the first true rib.

The false rib was dissected free and then removed by rongeur, with the exception of a small portion of the head.

The C VIII and D I roots passed up over the ligamentous extension of the cervical rib, but did not appear to be under tension of pressure. The subclavian artery also did not seem to be under tension.

After the operation there was numbness of the whole extremity, with considerable loss of power, especially in the shoulder muscles. There was tingling in the fingers, especially the thumb, index, and middle fingers. Tactile sensibility was much diminished.

On the second day the congestion and cyanosis had almost disappeared and sensation and power began to return. Between the eighth and twelfth days he had several attacks of sharp pain. Aside from this his convalescence was uneventful and rapid.

Within three months the extremity became normal and has remained so.

Comment: In this case the symptoms were severe, though the rib was so small that even the radiologist refused to diagnose it as cervical rib. The result after the operation proves, however, that the aponeurotic attachment was enough to give him those symptoms.

I wish to express my sincerest thanks to Dr. A. S. Taylor for helpful suggestions.

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PAIN DUE TO ILIO-COSTAL IMPINGEMENT.*

BY F. J. GAENSLEN, M.D., MILWAUKEE, WIS.

IMPINGEMENT of the costal margin on the crest of the ilium as a cause of persistent pain, while not common, appears to occur with sufficient frequency to merit consideration. During the last five years the writer has observed five cases. I am indebted to Dr. H. C. Schumm, my associate, for notes on two other cases occurring in his hospital services. In severe cases of scoliosis it has been recognized as a not infrequent cause of pain by numerous writers, Lovett, Whitman, Tubby, Spitzy, etc. In many of these cases of scoliosis the impingement is so definite that it is evident even on casual examination, and the patients themselves may make the diagnosis for us. Pain along the costal margin as a result of impingement occurs, however, in a variety of conditions in which the impingement is not at once obvious, and unless this possibility is kept in mind, diagnosis may offer difficulties.

Since no mention has been found in the literature of its occurrence in any condition except these severe scolioses above referred to, it has seemed worth while to collect the cases observed and to report them briefly. In all the cases to be reported the pain was located definitely at the lowermost portion of the costal margin where this lies closest to the crest of the ilium. Not only was there pain at this point, but also local tenderness, and this pain and tenderness could be produced at will by pressure on the costal margin at the point indicated. In examining for this condition it is best to have the patient sitting as erect as possible, then to crowd the examining fingers under the costal margin, and finally to allow the patient to assume a relaxed sitting position, if necessary, with the trunk inclined slightly forward and to the affected side.

If impingement is the important factor, the pain which the patient complains of can be produced at will by this manoeuvre. While some discomfort is elicited on the sound side as well, it is not so acute or definite as on the affected side.

Referred pain at this point can be ruled out by the fact that the tenderness is confined to the comparatively small area of potential con-

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tact rather than along the entire length of the lower ribs. The association of tenderness localized at the point of impingement is helpful, therefore, in distinguishing pain due to impingement from referred pain due to a vertebral or costovertebral lesion or to pressure symptoms of a long transverse first lumbar process on the twelfth rib, to which Goldthwait called attention in a recent paper.

In the erect standing position the costal margin clears the crest by a safe margin of about three fingers. In the slouching attitude this clearance is considerably decreased, while in the relaxed sitting position with the normal lumbar lordosis effaced and the dorsal curve increased, the space between ribs and crest is still more reduced. That there is actually only little space in the slouching or relaxed sitting position between these bony structures is readily demonstrated, even on the normal individual, by hooking the fingers under the costal margin and inclining the trunk slightly forward and to the side, when an uncomfortable sensation of pressure is produced. It will be readily understood that slight though continued pressure may give rise to very annoying discomfort or pain.

Anatomic variations will naturally play an important rôle in the production of such symptoms, a short lumbar spine or a sacrum deeply set between the wings of the ilia will be predisposing factors, while length of ribs and degree of flare of both costal margin and iliac crest will have important bearings. In several of the cases to be reported patients were of sedentary habit, which probably contributed to the production of the impingement and the consequent pain.

In males with well-developed thorax the costal margin will override the outer margin of the crest in extreme side bending and flexion, while in the female the costal margin is more apt to descend along the median aspect of the iliac crest. Inspection of a number of cadavers in the anatomical laboratory of the University of Wisconsin showed that impingement was readily produced by side bending of only moderate grade. Contact of costal margin and crest occurred between the upper border of the crest and the distal portions of the tenth and, particularly, of the eleventh rib. In none of the bodies examined was the twelfth rib long enough to interfere.

Since the lateral and anterior portions of the abdominal wall are supplied by the lateral and anterior cutaneous branches, respectively, of the intercostal nerves, it is conceivable that referred pain may be expected in these areas. In case of pressure, therefore, on the tenth, eleventh, or twelfth intercostal nerves, pain in the lower quadrant of

the abdomen may result which might be attributed erroneously to renal calculus or to appendicitis or other intra-abdominal condition. Such an error in diagnosis had been made in one of the cases to be reported, in which an appendectomy had been done.

Rogers, in 1911, in discussing faulty posture as a cause of referred pain, reported a case in which renal calculus or appendicitis was suspected, and operation considered by another surgeon because of pain about McBurney's point. Rogers attributed the pain to irritation of the ilio-inguinal and ilio-hypogastric nerves in their course through the psoas muscle, irritation of the nerve being explained by the constant straining of this muscle in the effort to maintain body balance in spite of faulty posture. Since these nerves, ilio-inguinal and ilio-hypogastric, supply the integument about the inguinal canal rather than the integument about McBurney's point, it would seem more likely that the pain was produced by irritation of the eleventh intercostal nerve which does supply the area about McBurney's point. Irritation of this nerve could readily result from impingement of the costal margin on the ilium. At any rate, correction of the faulty posture by means of a brace which, incidentally, would also correct an existing impingement, relieved the condition entirely.

X-ray studies have not been satisfactory. In the recumbent position, with spine flattened against the table, impingement is not likely, and in the standing position, with spine flexed and inclined to the side, the mechanical difficulties of demonstrating a lack of clearance are considerable. In several of our cases a long twelfth rib was shown. X-ray evidence is, however, scarcely necessary, since the possibility of impingement is so readily demonstrated without this, even in the normal person.

Treatment should be directed to correction of the deformity or faulty posture. As a therapeutic test adhesive plaster strapping may be applied in such manner as to produce lateral flexion of the spine away from the affected side. The same purpose will be accomplished by having the patient sit on an inclined plane higher on the sound side. In wage-earners, in whom the condition is pronounced, resection of sufficient portions of the distal ends of the ribs should be performed. This is especially true in cases where conservative treatment is not practicable or is not likely to lead to permanent relief. Of the cases here reported six were operated upon, with immediate and prompt relief. In one, an aged woman with osteoarthritis of the spine, a special corset and inclined seat were advised. In none of the cases in which x-rays were taken was there evidence of pathological lesion either of ribs or crest. No macroscopic changes were observed in the portions of ribs removed.

CASE REPORTS.

1. W. R. Age 40. Complaint: Severe pain in region of right hip.

Admitted to Milwaukee County Hospital in August, 1917. On examination patient showed kyphosis of considerable degree, centering over the 3rd and 4th lumbar vertebrae, following Pott's disease of many years' standing. Some hyperaesthesia in both flanks.

Treatment: Rest in bed with traction on both head and extremities. Latter discontinued a few days later because of alleged discomfort. Tenderness confined to crest of right ilium and portion of costal margin directly opposite.

Advised: Resection of ribs.

Operation, Aug. 22nd, 1917. Discharged from hospital on Sept. 10th, 1917. Completely relieved.

In a letter dated Oct. 7th, 1920, patient states that he has had complete relief and that he is working steadily.

2. B. A. Age 52. Complaint: Pain in legs, back, and left flank.

Admitted to Columbia Hospital on Dec. 23rd, 1919. On examination pain and tenderness found to be located at left costal margin opposite highest point of crest of ilium. This pain is continuous except during recumbency; also relieved by inclining the trunk to the right.

Reënforced corset holding spine erect gives considerable relief, but patient objects to constant use of this type of corset.

Operation, Feb. 3rd, 1920. Resection of about two and one-half inches of distal ends of eleventh and twelfth ribs. Completely relieved of pain.

This patient had a laminectomy done several years previously for supposed tumor of the spinal cord. There was also a scoliosis, but this was of such slight degree that it could not be held responsible for the impingement. There was, however, an abnormal forward bend with angulation of the spine in the laminectomized area and this appeared to be largely responsible for the impingement. The pain in legs and back was due to a diffuse cord lesion.

3. R. S. Age 83. December, 1921. Complaint: Pain along lower left costal margin.

Examination shows extensive osteoarthritis of the spine with ankylosis in the moderately flexed position. Because of patient's age, reënforced corset was advised; also, inclined seat with elevation on right, in order to prevent impingement of ribs and ilium on left side.

No recent reports.

4. W. F. Age 24. Seen at Rest Haven Hospital, Waukesha, by Dr. H. C. Schumm. Complaint: Pain in right side.

In fall of 1918, after summer of strenuous hiking and carrying of

heavy pack, patient began noticing sharp pains in right side beneath ribs. At first noticed pains only after carrying a heavy pack, but gradually noticed the pain after sitting or standing any length of time in one position.

In fall of 1918 condition was diagnosed as appendicitis and patient's appendix was removed. On recovery from the operation patient noticed that old pain was still present. This pain has persisted since then, sometimes better, sometimes worse. While not severe, it has made patient quite nervous.

Examination: Stands erect when at attention, but lapses into slouching position readily. No tenderness over spine or sacro-iliac joints. No muscle spasm.

Diagnosis: Pain over tips of 11th and 12th ribs caused by impingement against crest of ilium right side. Result of faulty posture.

X-ray shows very long 11th and 12th ribs. Advised operation.

Operation on April 6th, 1921. Distal three and one-half inches of right twelfth rib was excised, also two and one-half inches of distal portion of eleventh rib. Prompt relief was obtained.

Note on May 18th, 1921: No recurrence.

5. P. N. Age 33. Complaint: Pain in left flank for past two and one-half years. Intermittent, but worse after work.

This patient had Pott's disease of seven years' duration and had a tuberculous kidney removed three years ago. Has worn a spinal brace for one year.

Examination: Showed moderate rounded kyphosis centering over eleventh and twefth vertebrae. Process probably still active. Marked tenderness along left costal margin opposite highest portion of crest.

Operation in June, 1921, distal ends of ninth, tenth, and eleventh ribs resected.

No return of pain during the past eight months.

6. J. B. Age 60. Seen by Dr. H. C. Schumm, 1922, Milwaukee County Hospital. Complaint: Agonizing and continuous pain in left flank.

This patient had Pott's disease involving the mid-dorsal region, also tuberculosis of left elbow and pulmonary tuberculosis.

The impingement was very definite and caused such extreme and continuous pain that in spite of the general condition, resection of ribs was performed by Dr. Schumm under local anaesthesia for relief of pain.

Operation was followed by complete relief of pain due to the impingement, but patient died about three or four months later of a generalized tuberculosis.

7. A. R. Age 24. Complaint: Pain in back and right flank.

Examination: Right costal margin in close contact with right crest. Etiological factors are: Osteoarthritis with ankylosis of spine in moderately flexed position and faulty posture.

Leather corset constructed which relieved pain in back to considerable extent, but pain along costal margin proved unchanged.

Operation: Resection of ribs on April 10th, 1922, with complete relief.

Patient reported on April 28th. No recurrence.

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BEEF BONE IN STABILIZING OPERATIONS OF THE SPINE.

BY LLOYD T. BROWN, M.D., F.A.C.S., BOSTON, MASS.

INTRODUCTION.

THE following paper is a report of the use of an heterogeneous bone transplant, such as beef bone, in stabilizing operations of the spine. It is not a discussion of the relative merits of the different types of stabilizing operations. It confines itself entirely to the results which have been found in a series of cases which have been followed up to a period of five years after the operation.

The method followed in looking up the cases was that recommended last year by the Commission appointed by the President of the American Orthopedic Association to investigate the results of Ankylosing Operations of the Spine. The following statistics are taken from cards similar to those used by the Commission.

TYPE OF CASE.

There have been thirty-four cases operated upon in which the beef bone has been used for stabilizing purposes. All the operations have been done by members of the orthopaedic staff of the Massachusetts General Hospital, and with rare exceptions the same technique has been used.

Twenty-nine cases were diagnosed as tuberculosis of the spine; four cases, fracture of the spine, and one case, anterior poliomyelitis. In this last case the operation was done because of pain and inability to sit up from lack of enough muscle to support the lumbar spine on the sacrum.

Twenty-one patients were males and thirteen females. The four fractured spines were males, and the anterior poliomyelitis case was a female.

The ages varied from thirteen to forty-seven years. Of the tubercular cases among the males, four were in the second decade, the youngest being thirteen, the next sixteen, and two at seventeen. Six were in the third decade; five in the fourth decade and four in the fifth decade, the oldest being forty-seven. Among the females two were in the second decade, thirteen and eighteen years, respectively; seven in the third; one in the fourth, and two in the fifth, the oldest being forty-five. Of the fractured spines two were in the second decade, sixteen and seventeen years,

respectively; one in the fourth and one in the fifth, the oldest being forty-three. The anterior poliomyelitis patient was thirty-seven years old.

The occupations were as follows:

	Tuberculosis		Fractures	Anterior
	Males.	Females.		Poliomyelitis.
Automobile repair.....	2			
Salesman	2			
Housework		8		1
Photographer	1			
Musician	1			
Railroad	1			
School	3			
Teamster	2			
Baker	1			
Seaman	1		1	
Laborer	1			
Soldier	1		1	
Stenographer		1		
Carpenter	1			
None	1	1		
Shop		1	2	

The duration of symptoms before operation in the males with tuberculosis varied from four months, in a boy of thirteen who had an old tubercular process in the hip with a rapidly developing kyphosis in the spine, to ten years, the average being about four years. In the females with tuberculosis the duration of symptoms varied from six months to fifteen years, with an average of about three years. In the fractured spines the duration of symptoms before operation varied from two months to three and a half years. The operation seemed indicated in the latter case because of an increasing scoliosis and increasing paraplegia. The operation on the anterior poliomyelitis case was done two years after the beginning of the disease.

The occurrence of paraplegia varying in degree from weakness of the legs to complete paralysis, present either at the time of operation or with a definite history of it, was found in both the male and the female cases of tuberculosis eleven times; six times, or 28½%, in the males, five times, or 38.4%, in the females.

The occurrence of abscesses was noted under two headings: One, those which could be palpated, and the other, those seen in the x-ray. In one

case it was found that a psoas abscess which had made its way into the thigh did not show in the x-ray. In the males, abscesses were palpated in three, or 14.3%, of the cases, while by x-ray they were found in seven, or 33.3%. In the female, abscesses were present by palpation in three, or 23%, and by x-ray in ten, or 76.9%. No definite relationship could be made out between the occurrence or non-occurrence of paraplegia and abscess as to cause and effect. Abscesses occurred with and without paraplegia an equal number of times.

The disease was found in all the vertebrae from the fourth and fifth dorsal to the fifth lumbar. It was present five times at the eleventh and twelfth dorsal, and five times at the first and second lumbar, four times each at the seventh and ninth dorsal, thrice each at the eighth and twelfth dorsal, twice at the fourth and fifth lumbar, and once each at the fourth, fifth, sixth, tenth, and eleventh dorsal and second and third lumbar.

The occurrence of more than one focus of tubercular infection was noted in fourteen, or 48.2%, of all the cases: Nine, or 42.8%, of the males and five, or 38.4%, of the females. There were six cases, or 20.7%, that had two distinct foci in the spine itself, with at least one unaffected vertebra or disc between the foci. Of these, four were males and two were females. One case of a man who gave a definite history of, and still had, a discharging sinus from a tubercular peritonitis, later showed two separate foci in the spine for which a beef bone transplant was put in, is now being treated for a tubercular hip which shows in the x-ray a typical tubercular picture. Another patient, a woman, who had previously been treated for tuberculosis of the lungs, developed a focus in the spine and still later a focus in the sternum, which required an operation. A third patient, beside two definite foci in the spine, gave a history of pleurisy. There were two spinal cases which had old hip disease, both males; four cases that had had pulmonary disease, one male and three females; two males with a genito-urinary infection.

TECHNIQUE OF OPERATION.

The technique of operation is divided into three main headings, because in the treatment of tuberculosis of the spine the operative procedure is considered to be only an incident. (1) Preoperative care. (2) The operative technique. (3) Postoperative care.

PREOPERATIVE CARE.

No attempt will be made to describe the treatment of the non-operative cases even though, except for leaving out the operation itself, the treatment is in many cases the same.

The question of the diagnosis comes first. The chief point brought out by this investigation is the possibility of the occurrence in adults of more than one focus of infection in the spine. Six cases, or 20.7%, of the total number of patients operated upon showed two foci in different parts of the spine. In two of these the second focus was discovered before the operation, but in four cases it was not found first. The probable cause for missing the condition was that the x-rays did not include enough of the spine to clearly show both foci. Therefore, in adult cases especially, it is advisable to have an x-ray study both anteroposterior and lateral of the entire spine, from the sacrum to the cervical region.

The next important step after the diagnosis has been made is the preoperative care. In this series of cases it has been the custom to make use of the plaster-of-Paris bed or posterior shell. The reasons for the use of the shell are: first of all, it greatly increases the comfort of the patient. It also makes the handling of the patient, which is necessary for the proper treatment, much more simple, and lastly, by careful moulding of the shell it is possible to maintain not only some correction of the kyphos, but also, by keeping the ribs and chest in a position of expansion, to prevent the tendency to deformity that may occur in prolonged recumbency, thereby interfering with the most perfect physiology of the body which is so necessary in recovery from tuberculosis.

The posterior shell is made with the patient lying on the stomach with pillows so arranged that the lumbar spine is in a position about half-way between the extremes of its possible curves, that is, in neither full extension nor flexion. If the disease is in the lumbar region, as much correction as possible is obtained without force or pain. The shell is made so that it extends from the top of the head to just above the knees. A hole is later cut out to make possible the use of the bed pan. Special care is taken as the plaster is setting to mould the plaster into the loins at the costovertebral angle so that the ribs and the loins will be supported and the chest will thereby be kept in a position of expansion while the patient lies upon the back. This point cannot be too strongly emphasized because of its marked effect on the patient's general condition. It has been found that in those cases which have had properly fitted shells there has been less difficulty in getting them on their feet later on. The other place where careful moulding is important is at each side of the spinous processes the whole length of the cast, so that the patient lies on the erector spinae muscles or posterior angles of the ribs and thus gets no pressure on the spinous processes or the sacrum. When the posterior shell is made and thoroughly dried, the patient is placed in it and an an-

terior shell is made. If the disease is below the ninth dorsal it is not necessary to make a chin piece; if above the ninth dorsal, the chin piece is a help later on in turning the patient. It is advisable to have the anterior shell come down as far as the knees. When the two shells are made the patient is kept on the posterior shell for at least a week in order to make sure that it is comfortable and to eliminate the danger of decubitis sores. This period of recumbency also helps to relieve the congestion in the spinal muscles and thus facilitates the operation. Twice a day the anterior shell should be strapped on to the patient and the patient rolled on his face so that the back can be attended to. The anterior shell is used for the patient to lie in at the time of the operation, thereby eliminating as far as possible much of the strain that comes at such a time in the necessary moving.

PREPARATION OF THE BEEF BONE.

Gallie reported two operations done in 1915 in which he used a piece of the femur of the beef in two cases for immobilizing the spine. He points out the importance of having a cancellous portion as well as a cortical layer. Gallie also used a dog's tibia. He suggests that beef ribs split open are excellent. For this reason it was thought that the rib of the beef would be practicable. By cutting it at right angles to its flat surface it was possible to get not only two layers of cortex with a cancellous area between, but also to make use of the natural curve of the rib to fit the kyphos of the spine. It also seemed that the cortex of the rib was not nearly so dense as that of the femur and would probably allow the more easy penetration of the blood-vessels and osteoblasts into the dead bone. The strength of a rib splint depends upon the width which the splint is cut, usually one eighth of an inch, and the fact that the splint is cut from the rib in the direction of the fibres of the bone. It is surprising the strength the splint has if the force is applied in the direction of its natural curve. Laterally it has very little strength, but lateral strength is not needed necessarily in the desired fixation of the spine. (See Fig. 1).

The preparation of the rib splint is as follows: An ordinary beef rib is obtained from the butcher. This is boiled for an hour, thus making possible the easy removal of the muscles and ligaments. The splint can now be cut with an ordinary saw or a motor saw to fit the kyphos. By means of a tracing of the kyphos, accurate fitting can be accomplished. It is well to have several splints, and this is easily done, as several can be made from the same rib. The splints, so prepared, are boiled twice more

FIG. 1.—Beef Bone Splints. On left, lateral view showing two layers of cortex with marrow between. Also the amount of curve shown by the average rib. The middle figure shows the front view of a splint. The figure at the right shows a splint removed from a patient four and one-half months after it was inserted, because of sepsis.

for an hour at twenty-four hour intervals. It is necessary, therefore, to begin to prepare the splint at least three days before the time for operation.

PREPARATION OF THE PATIENT FOR THE OPERATION.

The technique of preparation used in this series of cases was to have the patient shaved and given a soap-and-water scrub with a sterile brush by a nurse who had scrubbed up as if for an operation. After ten minutes with soap and water the skin is cleaned with alcohol and this is followed with corrosive. A dry sterile dressing is put on until twenty-four hours later, when the same technique is again used. The second sterile dry dressing is not removed until the final preparation at the time of the operation the following day.

OPERATIVE TECHNIQUE.

When the operation is performed it is well to remember the points mentioned by Gallie and others: namely, accurate and perfect contact of the splint with the open cancellous surfaces of the spinous processes;

that there should not be more than three-quarters of an inch of the splint between contacts with living cancellous bone, and that each end of the splint should be buried in a spinous process.

The patient is brought to the operating room in the posterior shell and anaesthetized while still in the shell. When anaesthesia is complete the anterior shell is put on and the patient turned over. The operation is performed with the patient in the anterior shell.

The skin in this series of cases at the time of the operation was for the most part prepared with the usual iodine technique. The skin incision was carried down to the spinous processes, as little of the subcutaneous tissue being dissected as possible. The spinous processes were split with a chisel. In most of the cases a combination of the spine-splitting and the fusion operation was performed, because it was felt that by adding the fusion to the spine-splitting operation there would be more raw bone surfaces brought into contact with the bone splint. When the spinous processes were split, one-half of the spinous process was cut away from its base, and the periosteum with the spinous process attached was scraped back so that the laminae and the articular facets were exposed on one side. The laminae were then furrowed with a gouge and the bone splinters laid back into the periosteal trough so that they overlapped each other and bridged the spaces between the laminae of the adjacent vertebrae. The articular facets were curetted. The beef bone splint, which had been boiled again with the instruments, was now fitted into place as accurately as possible, care being taken not to have too great a space between the living bony contacts. The periosteum was sewed over the splint, bringing its edges as close together and as tight as possible. Special care was taken in placing the skin sutures, getting the best possible approximation. A dry dressing was applied and held in place with adhesive. The posterior shell was next applied and the patient rolled over into it upon the back and sent to bed on a Bradford frame, the latter being used simply for convenience in the nursing care.

POST-OPERATIVE CARE.

The immediate post-operative care consisted in the two-hourly shifting of the patient and the posterior shell slightly from one side to the other, until the danger of a decubitus sore had passed, which was usually in eight to twelve hours. The stitches were removed in two weeks. The patient was kept in the posterior shell for six weeks. Where possible, in the light of our experience, it would be well to prolong the period of recumbency much more than this. At the end of this time in most of the

cases of this series a plaster jacket was applied, and for the next six weeks the patient was allowed to begin gradually to sit up and to walk around. At the end of twelve weeks from the time of the operation a back brace was applied. This brace was usually made of about fourteen to sixteen gauge spring steel, thus making a support which was not of the rigid type, but did give some support by lessening the strain on the muscles of the back. The patients were advised to wear this brace for at least one year from the time they were operated upon.

POST-OPERATIVE STAGE.

An analysis of the cases in the post-operative stage gives the following results. Thirty of the thirty-four cases healed by first intention, only four of the thirty showing a slight serous discharge from the suture holes for a few days. In one case (Case 27), which had healed by first intention, the wound broke down thirty-three days after the operation and the bone splint was subsequently removed. In this case a tubercular abscess, unsuspected before operation, had been opened into at operation. Two cases (Cases 18 and 22), one from a pressure sore developing after operation and one from an abscess caused by a kidney function test breaking into the operated area, subsequently discharged their bone splints. Two other cases died from septicaemia soon after operation. One (Case 4) was undoubtedly caused by insufficient care being taken in allowing the visitors at the operation opportunity to inspect the bed prepared for the beef bone splint. The second case (Case 31) occurred in a soldier who three years previously had been filled full of shrapnel and at intervals from that time had had skin infections. This operation was done, recognizing the danger of infection, but the condition of increasing spinal deformity and paraplegia whenever he attempted to be on his feet made the operation seem advisable at the time.

The stitches in all the cases were removed on the eighth to the fifteenth day, the longer time being preferred, it being found that there was less tendency at a later date to have any spreading of the scar.

POST-OPERATIVE CLINICAL FINDINGS.

An analysis of the last reports received from the whole group, varying from one year to four and a half years, showed that nineteen were in excellent general condition; four had died as a result of the operation; four were not helped by the operation; four cases were reoperated upon, two because of fracture of the bone splints and two because the splints did not immobilize the second focus.

It was possible to examine twenty-three of the thirty-four operated cases during their post-operative period at intervals up to four and one half years. Notes on eighteen of these show that the operative area was solid and firm and there was a broad ridge of bone much wider than the normal spinous processes. In the middle of most of the spinous processes there could be felt a definite sulcus, and connecting these sulci a definite bony bridge. Three cases where the end of the bone splint was not in contact with the spinous processes showed that the end of the bone splint was freely movable and felt like cartilage.

Six cases which complained of pain a year or more after their operation, were examined and the cause of the pain was found to be not disease, but strain from postural deformities. These cases were relieved by the proper training to compensate for the deformities.

EFFECT OF OPERATION ON PARAPLEGIA.

It seems to the writer that it is impossible to state whether recovery from paraplegia, especially in the above series, was due to the operation or to the prolonged recumbency. Of the eleven tubercular cases of paraplegia, varying in degree from weakness to complete paralysis, it was possible to trace ten. Nine of these ten recovered within the course of one year. One case showed an increase of the paraplegia, which later at an operation for laminectomy was found to be due to the tubercular abscess having broken into the spinal canal and causing direct pressure on the cord. There were two recurrences of paraplegia, both due to a secondary focus in the spine not recognized at the first operation. One other patient developed paraplegia, where she had not had it before operation, after she had fractured her beef bone splint.

One case of fractured spine with complete paralysis before operation, as was expected, showed no change in the paralysis. The operation in this case was done not only to prevent the marked increase of deformity that was coming in the spine but also to prevent the associated effects on the abdominal physiology from the crowding of the abdominal organs. The infantile case showed no change except possibly some increase in the power of the glutei.

EFFECT OF OPERATION ON ABSCESS.

Of the three male cases in which an abscess was palpated before operation one reported by letter three and one half years later that the abscess had opened. This abscess was still discharging freely when seen

four and a half years after operation. Another had the abscess aspirated several times in the following two years but the abscess has now disappeared. The third was noted a year post-operative as filling up.

Of the seven male cases which showed the presence of an abscess by x-ray, four showed the abscess unchanged in the x-ray a year or more after the operation; no data could be obtained on one case, and two cases had the abscesses opened later on. One of these is the case mentioned above. Of the three female cases in which the abscess was palpated beforehand none have given any symptoms, the longest post-operative time being two and a half years, and the shortest a year. Of the ten female cases in which abscesses were found by x-ray there were no symptoms noted.

POSTOPERATIVE X-RAY FINDINGS.

An attempt was made to find out by examination of the x-rays, if new bone formation occurred and if there was evidence of fusion of the vertebrae. This proved to be very unsatisfactory because of the lack of uniformity of the x-rays as to exposure, etc., and to the variable personal equation in interpretation.

The post-operative x-ray findings were grouped under the following headings. Not every x-ray would bring out all the points noted.

(*a*) New bone formation—This would be evidenced by an increased density in the diseased vertebrae as shown in different x-rays.

(*b*) Fusion of vertebrae—as shown by the disappearance of the intervertebral discs and growth of new bone across the intervertebral space.

(*c*) Abscess—change in size; presence or lack of calcification as shown in successive x-rays.

(*d*) Beef bone splint—does it still show in anteroposterior and lateral views; change in density as compared to the spinous processes; change in size; position in relation to spine; presence or absence of fracture.

(*a*) New bone formation. It was possible to obtain post-operative x-rays in ten of the twenty-nine tubercular cases, one fractured spine, and one infantile case. These x-rays varied in length of time from four months to four years post-operative. Five tubercular cases showed definite evidence of new bone formation, and in five no change could be made out. Four males and one female showed the bony changes.

One fractured spine nearly four years post-operative showed evidence of proliferation in the spinous processes but nowhere else. The infantile case showed no evidence of new bone formation.

(*b*) Fusion of vertebrae. Of the ten tubercular cases in which it was possible to get the late results by x-ray examination, three male cases and one female showed evidence of fusion of the vertebrae. No such evidence was seen in the fractures or the infantile case.

(*c*) Abscesses. It was possible to obtain notes by x-ray of ten tubercular cases. Of these, six cases, four males and two females, showed no sign of calcification and no change in size of abscess. One female showed an increase over the marked amount of calcification she originally had. This was the case that had had her disease for fifteen years and had been completely paralyzed at two different periods. Two other women, one a year post-operative and one because of the infection due to a tubercular abscess breaking into the wound with the subsequent loss of the bone splint, followed by recumbency for two and a half years, showed some calcification of their abscesses. One male case also showed, nearly four years post-operative, slight calcification in the abscess.

(*d*) Beef bone splint. In eleven cases, five males and six females, the beef bone splint was found in the anteroposterior post-operative x-rays as long as four years after it was put in. It was found in only eight of the lateral pictures, five males and three females. This difference was due to the fact that in lateral views of the upper dorsal spine it is very difficult to demonstrate the spinous processes, as the angle of the ribs interferes.

DENSITY OF BEEF BONE SPLINT.

In eleven cases, six males, five females, including one fracture and one infantile case, the density of the spines and the beef bone splint was the same. These observations were made on plates taken from one to four years after the operation. One case taken four months post-operative showed that the spinous processes and the splint were of a different density.

CHANGE IN SIZE OF BEEF BONE SPLINT.

Eight patients, four males and four females, showed no change in size of beef bone splint. One male, a fractured spine, which showed hypertrophy of the spinous processes, showed, also, what seemed to be a slight hypertrophy of the splint itself.

POSITION OF SPLINT.

Thirteen patients, eight males and five females, showed that the splint was in place, but that in practically all the splint was nearer the tip than the base of the spinous processes. In one case, the upper extremity, and in another case the lower end of the splint was not in contact with the spinous process.

Five cases showed a break in the continuity of the beef bone splint. One patient, fifteen months, and one two and three quarters years post-operative, showed no clinical symptoms. A third patient, seventeen months post-operative, had a recurrence of pain which was probably caused by too hard work, since the symptoms disappeared with a few days' rest. It is possible that this break in continuity in the beef bone splint in the cases showing no clinical symptoms may be due to absorption of the splint. Two patients showed recurrence of their preoperative condition and were operated upon again. These cases are reported later.

TIME OF RETURNING TO WORK AFTER OPERATION.

In spite of careful instructions given to patients not to return to work for at least six to eight months after operation, it was found that one went to work eight weeks post-operative. This man felt so well that he lifted a stove and fractured his bone splint, was reoperated upon, and now has a secondary focus in his dorsal spine. Other patients varied from five months to two years before returning to work. Fourteen patients, six of whom were females and were doing housework, had returned to their original work. The remaining patients either changed their work or were not working.

DEFORMITY OF SPINE AS AFFECTED BY OPERATION.

Accurate information could not be obtained upon this point, but from what could be made out ten cases showed less deformity, six cases no change, and two cases an increase of deformity. Of the last, one was due to a fracture of the graft and the other is still under observation fifteen months after operation.

LENGTH OF TIME SUPPORT WORN AFTER OPERATION.

Eleven patients were wearing the back brace at the time the last note was made. In some of these it was four years post-operative. The braces were worn not because of pain, but because, as the patients said, they felt

less tired and safer when they had to do hard work. In these cases the support was not worn constantly. One patient (Case 11) removed his support in nine months and had no pain, but three and a half years after his operation an abscess filled up and discharged in spite of his being in excellent general condition.

FUNCTIONAL RESULT.

By functional result is meant not only what happened in the operated area but also what happened to the patient. There were twenty-four cases from which it was possible to get information from one year to four and a half years after the operation. Seventeen were in excellent general condition and were having no symptoms referable to the disease or to the condition for which they were operated upon. Two others had died of an intercurrent infection without having had any trouble with the spine after the operation. Four of the twenty-four cases came to secondary operation; two for fracture of the bone splint. In one of these the splint was not strong enough to mechanically stand the strain put upon it and in the other the patient abused his back. The other two were reoperated upon because of secondary foci not recognized at the time of the first operation. Two of these four cases are now in excellent condition. In three other cases the bone splint was removed. Of these three, one is perfectly well, one has died, and one* has been lost track of.

There were six deaths, or 17.6%, in the series of thirty-four cases. Two died immediately post-operative from septicaemia as stated above; one from miliary tuberculosis, four and a half months post-operative; one from pulmonary tuberculosis two years post-operative; one after a laminectomy for progressive paralysis one year post-operative, and one from an intercurrent infection two years after operation.

As has been stated above, four cases came to secondary operation: two because of fracture of the bone splint and two for secondary foci. These were performed from eight to eighteen months after the original operation. At these operations there was found no evidence of irritation or inflammation around the bone splint. In one case (Case 11) the cancellous portion had been replaced by connective tissue and the two cortical layers were in a fibrous tube between and through the spinous processes.

*This patient, Case 18, has recently been seen. He has been at a State sanatorium, where he was kept recumbent until the sinuses healed and then was made to get up and around without support, with the result that he is having symptoms again from the original disease.

In a second case (Case 17) there was found no attachment of the splint to the spinous processes.

In the third and fourth cases (Cases 14 and 16) the splint seemed to be attached to the spinous processes. An interesting feature was that the splint stood up like an I beam in the middle of the spinous processes and that the spinous processes were flared outward, making the ends much broader than normal. In no case was there found any evidence of the spinous processes fusing together.

Histological examinations were made of the specimens procured at the above operations and showed no evidence of new bone formation in two cases, slight evidence in one case, and in a fourth case active proliferation of bone which was apparently extending into degenerate cortical bone. These examinations were made by Dr. H. F. Hartwell of the Pathological Department of the Massachusetts General Hospital.

One of this series of cases died of miliary tuberculosis four and one half months after the operation. The spine of this patient was removed and an histological examination was made. This examination, as well as those on the experimental animals, was made by Dr. L. W. Smith of the Pathological Department of the Harvard Medical School. (See report of Case 23).

Some experimental work was done at the Surgical Pathological Laboratory of the Harvard Medical School with the help of Dr. William A. Cochrane to determine which of the three following methods gives the firmest stabilization of the spine. Two experimental dogs were used and all three types of operation were done on different parts of each animal's spine. In the dorsal region a fusion operation was done on three vertebrae according to the method of Hibbs, except that the spinous processes were cut into several thin longitudinal fragments. These fragments were placed to overlap each other. The next two spinous processes below this area were split and a fusion operation was done on the laminae and articular facets on one side only. The beef bone splint was put in so as to be in contact with the open cancellous layer of these spinous processes. Skipping the next spinous process the two processes below this were split and a beef bone splint was put in according to the method described by Albee. Immobilization for one month in a plaster jacket. (See experimental work, Cases 1 and 2).

One animal was killed fourteen weeks and the other twenty weeks after operation. Macroscopic examination of the first specimen showed that the firmest union was in the area of the fusion operation and the least firm in the spine-splitting operation. The second specimen showed

that there was no demonstrable motion in the region of the fusion or fusion plus beef bone splint. There was very free motion in the region of the spine-splitting operation.

REPORT OF CASES WHICH CAME TO SECONDARY OPERATION.

CASE 11. A. DeC., age 27. Female. Diagnosis: Tubercular spine involving twelfth dorsal. Duration, two years. No paralysis, no abscess. Slight deformity. X-ray before operation showed destructive process involving twelfth dorsal and first lumbar. September 19, 1919, a beef bone splint was put in by splitting the spinous processes, no attempt at fusion being made. The patient was put back in her plaster shell after the operation and kept in it for six weeks. The wound healed by first intention, the highest post-operative temperature being on the second day, 100.8 F. The stitches were removed on the thirteenth day, the wound being clean and dry. One week later there was a slight superficial infection in some of the suture holes, but these entirely healed at the end of two weeks. Patient had practically no post-operative discomfort. At the end of six weeks a plaster jacket was applied and she was allowed to be up and around. Three months after the operation she was given a spring back brace. Eight months after the operation an x-ray showed the beef bone splint extending from the third lumbar to the ninth dorsal, a small unexpanded abscess, no new bone formation, no change in density of graft. Thirteen months post-operative patient was comfortable. K. J. normal. No abscess felt.

About one and a half years post-operative, patient had pains in her back and a recurrence of symptoms with slight paraplegia. An x-ray showed a definite fracture of the bone splint at the apex of the kyphos.

Fusion operation January 15, 1921. The beef bone splint was exposed. It was perfectly white with no sign of irritation in the tissues. A clean sequestrum. It was cracked at the second lumbar level. The outer cortex of the splint was removed. The cancellous layer had been replaced by fibrous tissue; the inner layer of cortex, like the outer, was unchanged and showed no sign of bony attachment to the spinous processes. It was in a fibrous canal and was also cracked at the same level as the outer layer. The splint above and below the site of the disease was at the tip of the spinous processes and the spinous processes themselves below the splint were solid. Part of the splint was not in contact with the lower lumbar spines. There was no sign of bone formation in the interspinous ligaments. A fusion operation was next done on both sides of the spines. The spinous processes were split in many pieces and placed to fill in all

the intervertebral gaps. Pieces of bone from the laminae were also placed to bridge the gaps.

Laboratory examination February 17, 1921: "A long slender spicule of bone showing on microscopic examination degenerate cortical bone. There is no new bone formation."

CASE 16. W. T. C., age 31. Male. Diagnosis: Tubercular spine, first and second lumbar. Duration of back trouble, intermittent for ten years. Slight kyphosis, legs weak and very spastic. No abscess felt. X-ray before operation showed extensive destruction of first and second lumbar vertebrae and intervertebral disc. A large abscess shadow seen.

July 14, 1919, a beef bone splint was put in by splitting the spinous process and interspinous ligaments. No attempt was made toward fusion. The usual technique of closing the wound was followed and patient put into his posterior shell. Highest post-operative temperature 100.5 F. Stitches removed on the thirteenth day with slight sero-sanguinous discharge. Six weeks post-operative the patient's leather jacket, which he had had before operation, was applied, but it did not fit very well. At six and one-half weeks there was no unsteadiness in walking. Patient went to work, carrying tonic bottles, eight weeks after operation. A year later he lifted a stove and felt a crack in his back. X-ray showed that the bone splint extended only so that its lower extremity was in contact with one-half of the fourth lumbar spine, and there was a definite fracture of the splint just between the third and fourth lumbar spinous processes. Fourteen months after the first operation a second operation was done.

February 17, 1921: Operative exploration showed that the beef bone splint which originally had a cancellous layer between each cortical layer, was a solid piece of bone. It was white and seemed to have very small bleeding points. The splint seemed to be fused to all the spinous processes examined except to the fourth lumbar, which was below the fracture, and to the top of the third spine. The tips of the spinous processes were flared outward and the splint stood up in the middle like an I beam. The spinous processes were not fused together. A fusion operation was next done on the third, fourth, and fifth lumbar on both sides of the spinous processes; two pieces of the flared spinous process of the fourth lumbar were put in to fill in the gap between the laminae.

Laboratory examination, February 17, 1921: "An elongated bony spicule showing on examination active proliferation of bone which is apparently extending into degenerate cortical bone."*

*This case has been operated upon again since writing this paper. The operative and laboratory findings are appended.

April 29, 1922: The patient had a recurrence of the paraplegia and was running down hill. X-rays showed he had a secondary focus involving the ninth and tenth dorsal vertebrae. There was also a moderate kyphos. As this second focus was above the region immobilized by the original beef bone splint it was decided that a fusion operation should be done. This was performed after usual preoperative technique and all of the old beef bone splint was removed and sent to the laboratory for examination. The following examination was made by Dr. L. W. Smith, of the Harvard Medical School.

"Specimen consists of portions of a beef bone graft removed from a man two years after the original operation. At the time of operation complete bony union was found in this graft which had been inserted between the split spinous processes. The graft itself could still be identified, and showed no gross evidence of absorption.

"Longitudinal sections through the beef bone graft present an infiltration of the dead cortical bone by new fibrous tissue, apparently derived from the surrounding periosteum of the spinous processes. The picture is one of slow absorption of the beef bone with replacement by connective tissue rather than by any new bone formation. A few of the Haversian canals likewise show this fibrous tissue infiltration. There seems to be no definite union between the cortical bone and the surrounding tissue, except in the manner indicated. Cross sections through the tissue present essentially the same picture,—a marked response of the fibrous tissue to the presence of the foreign body, but no true stimulation to new bone formation."

Case 17. M. C., age 45. Female. Diagnosis: Tubercular spine involving eleventh dorsal. Slight kyphos. Duration, three years; had been paralyzed for two years, but had no paralysis at time of operation. Abscess felt in psoas region. X-ray showed partial destruction of eleventh dorsal with destruction of intervertebral discs between it and adjoining vertebrae.

November 6, 1919: Beef bone splint put in and a fusion operation done on the laminae and joints of one side from the eighth dorsal to the second lumbar; usual post-operative technique; stitches out on twelfth day. Wound clean and dry. Plaster jacket in six weeks and spring back brace applied four months after operation. Patient did very well for a while, but fifteen months after operation her symptoms of pain and weakness of legs had returned and further x-ray examination revealed a secondary focus between the first and second lumbar. Examination of

the previous plates showed this lesion to have been present at that time but it was not considered to be disease. Immobilization of the spine above this second focus evidently induced the activity in the second focus.

March 4, 1921: Second operation; beef bone splint exposed in its entire length. At the upper end it was not fused to the spinous processes. In the lower part it was surrounded by the spinous processes. The entire splint was intact and firm especially in the region of the disease. When it was removed there was a solid ridge of bone connecting the laminae practically the full length of the splint. Specimen of splint sent to laboratory for examination. A complete fusion was done from fourth lumbar to tenth dorsal inclusive. The spinous processes were cut in many small pieces which were placed on the laminae to overlap as much as possible. Spicules were cut off the laminae to bridge the gaps between the laminae.

Laboratory examination. 21-3-27. March 4, 1921: "Spicule of bone showing on microscopic examination degenerate cortical bone. There is a slight evidence of new bone formation."

CASE 14. M. E. S., age 47. Male. Diagnosis: Tuberculosis of spine and pleurisy. Duration of disease, about seven years. Disease at eighth and ninth dorsal. Rather sharp kyphos. Some paralysis; an abscess felt. X-ray shows bodies of eighth and ninth dorsal almost completely destroyed. Bodies of eleventh and twelfth dorsal vertebrae are fused, the intervertebral disc being obliterated.

August 4, 1920: Beef bone splint put in from fifth dorsal to twelfth dorsal, fusion operation being done on the laminae and joints of one side. The usual post-operative technique. Highest post-operative temperature 101.8 on the second day. Stitches out on the eleventh day and wound clean and dry. This patient was recumbent for three months and then a jacket applied for two months. A spring back brace was applied five and a half months post-operative. Nine months after operation, after patient had been up and around for a time, there was a recurrence of his symptoms. This recurrence may have been caused by the immobilization of the upper focus of the eighth and ninth dorsal causing increased strain on the eleventh and twelfth dorsal which had been considered fused and inactive.

April 26, 1921: Spine explored by median incision from eleventh dorsal to fourth lumbar. The exogenous splint was found firmly imbedded in fibrous tissue but not attached to spinous processes of the eleventh and twelfth dorsal. The spinous processes were markedly flared

FIG. 2.—X-ray of spine removed at autopsy from a patient who died of generalized miliary tuberculosis four and one-half months after beef bone splint was put in. Note the beef bone splint in the spinous processes.

outward at their tips and the splint stood up between like an I beam. The twelfth dorsal spine was displaced posteriorly so that the laminae were considerably back of the first lumbar. Periosteum from all the exposed spines was stripped back to the articular facets, and shavings of bones from the laminae placed in the periosteal groove. The spines were splintered and overlapped as much as possible.

April 26, 1921: The laboratory examination showed "A fragment of bone showing on microscopic examination connective tissue and cortical bone, some of which is new formed. There is no evidence of tuberculosis."

REPORT OF CASE WHICH DIED AND AUTOPSY OBTAINED.

CASE 23. I. M. J., age 28. Female. Colored. Diagnosis: Tuberculosis of spine and lungs. Duration of disease, one year. Vertebrae involved, sixth and seventh dorsal. Sharp kyphosis, no paralysis, no abscess. X-ray showed sixth and seventh dorsal vertebrae almost completely destroyed, also the intervertebral disc. Temperature normal.

February 25, 1921: Beef bone splint put in and a fusion operation done on one side of the spines and laminae. The usual post-operative technique was used. The convalescence was very stormy. For six weeks the afternoon temperature went to 104, from which it gradually went down to 101. At the end of four months it was nearly normal, and a cast was applied and she was able to walk. The operative wound was clean, and stitches were removed in the usual time, with no sign of infection.

Four and a quarter months after the operation the patient entered the medical ward, where she died of miliary tuberculosis. An autopsy was performed and the entire spine in the operated area was removed. Autopsy report showed tubercular ulcers of small and large intestines, tuberculosis of spine and adrenals, solitary tubercle of pons, miliary tuberculosis of lungs, liver, spleen, kidneys, etc. (See Fig. 2).

Report of histological examination of spine by Dr. L. W. Smith, Pathological Department, Harvard Medical School.

TUBERCULOSIS OF THE SPINE WITH BEEF BONE SPLINT.

First Vertebra:—The beef bone transplant is free at this level. There is considerable fibrous tissue proliferation about the graft, but at no point is it adherent or infiltrative in character.

Second Vertebra:—The bone transplant shows evidence of involvement in a tuberculous process to a very slight extent, with infiltration by the connective tissue, eating out irregularly rounded areas of bony substance. At one point a spicule of bone is firmly adherent to a mass of young connective tissue, in a center of which is a typical miliary tubercle measuring somewhat over 1 mm. in diameter.

Third and Fourth Vertebrae:—There is some suggestion of irregular channeling of one side of the bone graft with hemorrhage and connective tissue filling this area. However, it does not seem to be definitely growing into the dead cortical bone.

Fifth and Sixth Vertebrae:—The graft at this level shows close approximation of the newly formed connective tissue of periosteal origin, but does not show any definite infiltration into it.

Seventh Vertebra:—No invasion of the graft is noted at the level of the seventh vertebra.

Eighth Vertebra:—At the level of the eighth again some evidence of gouging out of the bone graft is noted, and these gouged-out areas are filled with connective tissue and occasional capillary vessels.

Ninth Vertebra:—At the level of the ninth vertebra a similar condition exists.

Dr. Smith's report was as follows: "The general impression from studies of the sections seems to suggest a gradual replacement of the bone graft by newly formed connective tissue arising from the peri- and endosteum of the vertebral tissue. It does not seem to suggest any true invasion of the cortex through the empty Haversian spaces as might be expected, and no bony replacement is noted at all in the sections. The process is apparently one of slight absorption of the dead cortical tissue and filling in of these areas by this newly formed tissue without any actual stimulating effect upon the periosteum to form true new bone . . . . The tissues are further complicated by the profuse fibrous tissue reparative action associated with the tuberculous lesions . . . One slide showed a spicule firmly adherent to a mass of young connective tissue in the center of which is a typical miliary tubercle measuring somewhat over 1 mm. in diameter."

These slides were sent to Dr. W. E. Gallie, who gave the following report:

"In looking over the slides I am impressed with the fact that the changes in the graft and along its edges are exceedingly slow. There is undoubtedly union between the graft and its bed in places, but these points of union are infrequent and they do not look strong. In many places the graft appears to be lying loose in its bed. Without a doubt the union is not nearly as solid as when unboiled bone is used. Within the compact bone there has been very little change. Here and there you can see blood-vessels, but many of the old Haversian canals are empty still. Further, there is very little evidence of absorption or replacement, except along the edges of the graft. This is in marked contrast to the appearance of an autogenous graft at four months. It is evident, therefore, that while the same changes can be expected in boiled bone when imbedded in living bone as one sees in unboiled bone, these changes are very much slower."

REPORT OF EXPERIMENTAL WORK.

These experiments were done at the Surgical Pathological Laboratory of the Harvard Medical School.

FIG. 3.—X-ray of spine of experimental animal No. 1 after removal, 14 weeks postoperative, showing three types of operation on same animal. A. Region of fusion. B. Region of fusion plus beef bone splint. C. Region where beef bone splint was inserted into the spinous processes.

CASE 1. Female dog. Medium size. Middle-aged.

Dog was anaesthetized, having had morphia. Skin shaved, and with careful asepsis, Dr. Brown, with Dr. Cochrane assisting, made an incision about the level of the shoulder blades to the crest of the ilium. The incision was carried down to the spines and in the dorsal region three spines were denuded of periosteum, and the periosteum was

scraped laterally off the laminae as far as the articular facets on both sides. With a gouge, spicules of bone were raised from the laminae and turned up and down. The articular facets were curetted, the spinous processes were then cut into several small spicules, which were detached from their base and put back so that each spicule overlapped with the next one. The next two spines below were now split longitudinally and one-half of each spine was detached from the base of the spinous process. The periosteum on this side, with its spinous process attachment, was then scraped off as far out as the articular processes. The articular facets were curetted. Thin spicules of bone were then raised from the laminae and laid in the outer edge of the wound. A previously prepared beef rib splint was approximated to the two spinous processes. The periosteum envelope with the spinous process fragment was sewed so that it was in close contact to the beef bone transplant. Skipping one spine, the next two spinous processes in a caudal direction were split and separated widely enough to allow the placing in of a segment of previously prepared beef rib. This was sewed in as the one above had been, with silk. Subcutaneous tissues carefully closed the wound, and the skin was sutured with silk. The animal was put into a plaster cast.

She made a good recovery from ether and at first seemed rather uncomfortable, but got along without much difficulty after that. The jacket was kept on for four weeks, when the itching became so severe it was necessary to remove it. The wound was clean and solid. At the end of fourteen weeks the dog was anaesthetized and killed. That part of the spine which had been operated upon was removed and saved for histological examination after photographs and an x-ray. (See Fig. 3).

Histological Examination. Case 1. "The sections through the experimental dog are unfortunately too unsatisfactory to draw any definite conclusions from. The fixation by alcohol gives such imperfect preservation of the cells that no adequate conception of any stimulative action upon the living periosteum can be detected."

Case 2. A large female dog. Operation performed October 15, 1921. Exactly the same technique was used in this animal as in Case 1. Cast was kept on about four weeks, when it was removed because of some superficial skin infection.

This animal was allowed to live for five months. During much of this time there was a discharging sinus at the upper end of the wound (the fusion end). The dog grew very fat.

FIG. 4.—X-ray of spine of experimental animal No. 2 after removal, 20 weeks postoperative, showing three types of operation on same animal. A. Region of fusion operation. B. Region of fusion plus beef bone splint. C. Region where beef bone splint was inserted into the spinous processes. Note practically complete disappearance of the beef bone splint.

At autopsy there was found a thick layer of fat over the back. On the right side was a large subcutaneous fluctuant abscess, which discharged considerable grumous material. On the left side of the spine in the area of fusion there were found some pieces of dead bone which seemed like the spicules of the spinous processes.

On removal of the spine it was found that there was no demonstrable motion in the fusion or the fusion plus beef rib splint area. There could be felt in this latter place a thickened area resembling the beef splint. In the third region where the beef bone splint had been placed in the spinous processes there was very free motion, and a firm fibrous area resembling the beef bone splint could be felt.

X-rays taken. Specimen sent for examination. (See Fig. 4.)

Microscopically, sections through the anterior bone graft show considerable replacement of the bone by connective tissue proliferation. There is apparently union in many places between this dead cortical bone and new connective tissue which is gradually replacing it. A few areas of calcification are noted, although these do not in any way represent bone, merely discrete islands of calcium deposited between connective tissue cells. There is much more marked relationship between the graft and the new tissue in this specimen than in the one previously studied. The process in general is the same, a replacement by connective tissue rather than by true bone. In the fusion alone there is a definite union of the two bony surfaces, with islands of cartilage undergoing ossification and forming true bone in contrast to the graft area. Sections here likewise show the suture material and its gradual replacement by connective tissue. In the lower graft no bone is found, but there is dense connective tissue which has apparently replaced the bone graft. At one point in this area there is a small island of newly formed cartilage, with a suggestion of true ossification in that trabeculae are being formed and calcium deposited in them. This probably represents a small portion of the graft, and may indicate that bone formation may occur following such treatment. From these two experiments it would seem that the fusion operation in the dog gave the firmest stabilization, the fusion and the beef bone the next, and splitting the spinous processes and using a beef bone splint gave the least stabilization in one case and none in the other.

CONCLUSIONS.

1. There is no more operative risk, as shown by the immediate and late postoperative results in the above series, with the use of the beef bone splint than with any other spinal operation. In fact, theoretically,

at least, there is somewhat less risk as there is only one incision and there is not as much denuding of the periosteum.

2. The results of this series show that splints made of beef rib when put into the spinous processes are tolerated by the body at least as long as four and one-half years with no sign of irritation or inflammation and only slight signs of absorption.

3. There are certain advantages in using the beef bone splint:
   a. The saving of time at operation by having the bone splint prepared beforehand.
   b. The saving of an extra incision such as is necessary in the use of an autogenous graft.
   c. The lack of pain which may be caused by a second bone operation.
   d. The possibility of preparing the bone splint before the operation for careful, accurate fitting even when the kyphos is very sharp.
   e. The strength of the splint is great and can be determined by its width.
   f. The possibility of getting a very long splint.

4. There are certain disadvantages in the use of the beef bone splint.
   a. The beef bone being dead can act only as a scaffold and the regeneration of bone may not be as rapid as with a living bone.
   b. The fact that the dead bone is a sequestrum. The results of the above series show that if it is a sequestrum, it is not an irritative one.

5. The results found in this series of cases and the two experiments on dogs make the writer feel that immobilization of the spine is better accomplished by fusion of the laminae and articular facets than by immobilization of the spinous processes by means of a beef bone splint, with or without the fusion of the laminae and articular facets on one side of the spinous processes.

6. Finally, that in this series of cases nearly one-half had more than one focus of tubercular infection and that six of these had two foci in the spine itself.

There has been one outstanding feature brought out by this investigation and also found by the Spine Commission last year. This is the marked lack of uniformity in the method of keeping the records. If we, as an Association, ever expect to be able to get any end-results which can be trusted, we must see to it that we ourselves or our house officers not only make reliable records before operation and of the operative procedure and findings, but also of the immediate postoperative condi-

tions, and, of equal importance, accurate and intelligent notes on the subsequent conditions. We must teach our internes as well as our medical students the important points to be noted in all the above-mentioned stages so that our records will not be full of unimportant details and the important facts left unnoted. Having been working for many months on such records, I feel very strongly about this.

I would suggest that the Spine Commission make out a card which will be an improvement on the one sent out last year, so that it will be possible to have some uniformity throughout the country in the records of our spinal immobilization cases.

REPORT OF CASES.

CASE 1. W. C. G. Male. Occupation: auto repairer. Diagnosis: tuberculosis of spine. Duration of disease, nine years. No paraplegia, no abscess before operation. Marked kyphosis. Left hip ankylosed by arthrodesis several years ago; probably tubercular. Disease by x-ray, seventh dorsal. Operation June 30, 1917. Beef bone splint used. Postoperative stage. Postoperative temperature first day 101.8. Convalescence uneventful. No definite effort made at fusion. X-ray report October 16, 1917: Beef bone splint is seen in the anteroposterior view from the third dorsal to the first lumbar. Seventh dorsal is diseased. No evidence of new bone formation. No fusion of vertebrae. An abscess noted in region of seventh dorsal. No calcification of the abscess. No change in density of splint. The splint is in place. June 4, 1920, patient in excellent condition. No pain in region of operation. No sign of psoas abscess. For some weeks has had pain in the low back when tired. Is still wearing his brace. April, 1921: By letter patient says he went to work seven months after operation at his old job. He now has no pain, no abscess, no weakness, and is still wearing his brace part time.

CASE 2. H. N. N. Male. Occupation: salesman. Diagnosis: tuberculosis of spine. Duration, two years. For eleven months slight paraplegia. Psoas abscess felt. X-ray examination before operation shows disease of first and second lumbar. Operation, September 26, 1917. Beef bone splint from eleventh dorsal to fifth lumbar. Postoperative stage. Postoperative temperature 100.5. Convalescence uneventful. Six weeks after operation abscess noted as being smaller and softer. March 25, 1922: Patient went back to his old work as a salesman ten months after operation. He wore his plaster for eleven months and the leather jacket for nine months more. Three and one-half years

after operation, after an attack of influenza, the psoas abscess began to discharge in the left groin. He had another attack of "flu" this year and when seen had been in bed for several weeks because of high evening temperature, which was considered by the physician an attack of influenza. During the past year he has not been able to work much because of pain in the stomach and getting tired. The back has not bothered him. Because of the symptoms he had gone back to the leather jacket. Up to a year ago he had gained thirty-two pounds. Examination shows patient looks very well. The operative wound is solid and firm. There is a sulcus felt in each spinous process and a bridge of bone can be felt in the interspinous spaces. Patient moves around freely in bed. There is a slight suggestion of a prominence of the tenth dorsal which is above the old operative area, suggesting the possibility of a second focus. No motion can be made out in the region of the operation.

CASE 3. A. J. D. Male. Age 25. No occupation. Diagnosis: tuberculosis of spine and lungs. Duration of disease, ten months. No paralysis. No abscess. X-ray shows disease of fourth lumbar. General symptoms before operation, severe attacks of vomiting. Operation May 3, 1918. Beef bone splint and fusion on one-half of laminae from tenth dorsal to first lumbar. Postoperative stage. Postoperative temperature 100.5, which continued throughout his stay at the hospital. After the operation he had vomiting attacks similar to those some months previous to operation. No infection of wound. December 10, 1919, twenty months postoperative x-ray shows the bone splint still present. It is the same consistency as the spinous processes and shows no sign of the cancellous portion of the beef bone splint. It has not increased in size. Six months after operation the psoas abscess was noted as filling up. March 25, 1920, patient was in very bad condition. Vomiting had returned. Examination showed involvement of the right apex. He was sent to the State Sanitarium, where he died later.

CASE 4. L. M. Diagnosis: tuberculosis of fifth lumbar. Died; septicaemia, postoperative.

CASE 5. C. V. Female. Age 24. Occupation: home. Diagnosis: tuberculosis of spine. Duration of disease, six months. Complete paraplegia for four months. No abscess. X-ray showed extensive destruction of fourth and fifth dorsal. Operation April 15, 1918. Beef bone splint and fusion from the second to the seventh dorsal. Postoperative stage, uneventful except for some drawing up of the legs. May 10, 1920: For one year after operation patient recovered from paraplegia so that

she could walk without assistance. When seen in 1920, patient was seven months pregnant. Examination at this time showed a complete bony bridge in the region of the operation. No motion could be made out. Some protective muscle spasm. X-ray was unsatisfactory except that it showed abscess formation in the region of the dorsal vertebrae.

CASE 6. M. R. Male. Age 28. Diagnosis: tuberculosis of spine. Occupation: photographer. Duration of disease, one year, nine months. No paralysis; no abscess. Considerable kyphosis. X-ray showed tuberculosis of ninth and tenth dorsal and intervertebral discs. Operation, October 26, 1917: Beef bone splint and fusion. Postoperative stage uneventful. Highest postoperative temperature 100.2 the first day. May 10, 1918, reports that back gives him no pain. Is not sensitive to jar. He feels stronger, is beginning to go without brace. May 12, 1921, patient reports by letter. He went back to his original work eight months after the operation. No abscess and no weakness of the legs. Two years after operation he had some severe pain, but does not complain of it now.

CASE 7. J. A. W. Male. Age 31. Occupation: musician. Diagnosis: tuberculosis of spine, tubercular peritonitis, tuberculosis of hip. Duration, six to nine years. No paralysis. Psoas abscess on right. X-ray shows tuberculosis of twelfth dorsal and first lumbar and ninth and tenth dorsal, with narrowing of intervertebral spaces. December 21, 1917: Ten-inch beef bone splint with fusion on one side of the laminae. Post-operative stage. Highest temperature first day 100.2. Convalescence uneventful. Eight months later psoas abscess had increased so much it had to be aspirated several times. February 20, 1922: Two years after operation while patient was working, having had no difficulty with his back, but still slight discharge from the old peritoneal infection, began to have severe pain in the right hip, which showed on x-ray definite signs of tuberculosis. He has been in a plaster cast for two years and is now in very good condition. Has no paralysis, no paraplegia. The psoas abscess can no longer be felt. There are no symptoms in the spine. Examination of the spine shows solid bony union with a bridge of bone the entire length of the operative region. X-ray February 20, 1922, shows evidence of disease between the ninth and tenth dorsal and twelfth dorsal and first lumbar. No evidence of abscess. The beef bone splint is still evident in both the anteroposterior and lateral views. The splint seems to be the same density as the spinous processes. Splint is in place, except possibly in the upper part.

CASE 8. C. R. F. Male. Age 28. Occupation: railroad. Diagnosis: tuberculosis. Duration of disease, seven months. No paraplegia. No abscess. X-ray shows extensive destruction of twelfth dorsal with involvement of eleventh dorsal and first lumbar. Operation June 5, 1918. Beef bone splint with fusion from eighth dorsal to third lumbar. Postoperative stage. Highest postoperative temperature 101, second day. Convalescence otherwise uneventful. February 3, 1920, x-ray shows an old tuberculosis of spine with marked proliferative changes. No definite shadow of bone splint made out. May 9, 1921: Said he went to work thirteen to fourteen weeks after operation. The operation relieved the pain and made his back feel stronger. He has had no abscess. He was glad he had the operation. Seen by the Spine Commission, which said, "ankylosis—good result." February 20, 1922, reports he is feeling fine and never thinks of his back. Examination shows that the patient handles himself freely. No motion can be felt in the spine in the region of the scar. A definite sulcus can be felt in the spinous process and a bony bridge can be felt between them. The spinous processes in the operative area are close together and are enlarged to one and one-half times their normal width. February 20, 1922, x-ray shows that the eleventh and twelfth dorsal and first lumbar seem fused. There is marked new bone formation and the abscess is calicified. The bone splint is not seen in the anteroposterior picture, but is seen in the lateral, and has the same density as the spinous processes. It has not increased in size. It is placed well down in the spinous process.

CASE 9. R. J. B. Age 40. Female. Diagnosis: tuberculosis of spine. Duration of disease, fifteen years. Complete paralysis with recovery later at two different intervals, the first time for fourteen months, and three years later for two years and seven months. Partial paraplegia at time of operation. No abscess could be felt. X-ray showed marked destruction of three dorsal vertebrae with abscess formation and calcification of abscess. Operation June 14, 1918. Beef bone splint. No attempt at fusion. Convalescence uneventful. X-ray December 16, 1919, showed much abscess formation and calcification. X-ray June 16, 1920, showed marked calcification of old abscess, marked destruction of sixth to ninth dorsal vertebrae. No definite evidence of beef bone splint. June 16, 1920, seen by the Spine Commission, which said there was ankylosis and good result. February 20, 1922, patient feels very well, better than for years. Can walk a good deal, but tends to get tired. Is doing her housework. She has no pain due to the old disease. The deformity she thinks is less than before the operation. No abscess

can be felt. There is no sign of paraplegia. She wears the brace occasionally, depending on the work she is doing. Is very glad the operation was done. Examination of the spine shows it is firm and solid in the operative region, with no tenderness. A sulcus can be felt in the spinous process and the bone splint can be felt in the interspinous spaces. Knee jerks not exaggerated. No clonus. X-ray February 20, 1922. Disease at the seventh, eighth, and ninth dorsal. Very large abscess with extreme amount of calcification. The beef bone splint can be seen in the anteroposterior view. The density of the splint is the same as of the spinous processes and can be seen extending from the fifth to the eleventh dorsal.

CASE 10. T. T. Age 17. Male. Occupation: none. Diagnosis: tuberculosis of spine. Duration of disease, two years. No paraplegia; no abscess. X-ray shows disease of the fourth lumbar. Operation June 23, 1919: Beef bone splint and fusion. Postoperative stage. Highest postoperative temperature second day 101.2. Convalescence uneventful. February 7, 1922, general health very good. Has been working six months as a waiter. No abscess can be felt, no paraplegia. Bony bridge can be felt in the operative area. The operative area feels like a broad, heavy ridge of bone. Lateral motion suggests mobility at the level of the third lumbar. X-ray at this date shows the bone splint from the first lumbar to the first sacral. There is loss of continuity of splint between the second and third lumbar. There is no sign of fusion of the splint to the spinous processes. Density of splint the same as of the spines. The vertebrae give definite evidence of calcification, particularly near the narrowed intervertebral disc. No sign of abscess.

CASE 11. A. DeC. Age 27. Female. Diagnosis: tuberculosis of spine. Case reported above under heading, "Report of Cases which Came to Secondary Operation."

CASE 12. L. J. C. Age 13. Male. Occupation: none. Diagnosis: tuberculosis of spine and hip. Duration: tuberculosis of hip nine years; spine four months. No paralysis, no abscess. X-ray July 25, 1920. Complete obliteration of hip-joint. Extensive destruction of head and acetabulum. Almost complete destruction of eleventh and twelfth dorsal vertebrae. Operation October 22, 1920. Beef bone splint. No attempt at fusion. Convalescence uneventful. Highest postoperative temperature second day, 102. A plaster jacket applied in twenty-eight days. Sent home for further recumbency for two months postoperative. February 11, 1922, patient feels fine, but if he sits down long his back

gets tired and there is some soreness in the right loin. He has no pain referable to the old disease. The deformity was somewhat lessened by the operation, according to the patient's word. No abscess can be felt, no sign of paraplegia. Examination shows that the upper portion of the splint is free and can be moved above the spinous process. The rest of the splint can be felt as a firm bridge of bone from the eighth dorsal to the third lumbar. There is some spasm of the lumbar muscles. February 11, 1922, x-ray shows the disease at the eleventh and twelfth dorsal vertebrae, which are practically absent, with slight involvement of the tenth. There is definite evidence of calcification of the bones and there seems to be fusion between the two destroyed vertebrae and one-half of the tenth. An abscess is present in the x-ray, but shows no calcification. The beef bone splint can be seen in the anteroposterior and lateral views. There is definite lack of continuity in the splint at the apex of the kyphos. The splint is not in contact with the second and third lumbar and with only a small part of the first lumbar spine. The splint touches the seventh dorsal spine, but there is a space between it and the spinous process. There is no sign of fusion of the splint to any of the spines. The ninth and tenth spinous processes overlap the splint but do not seem to be fused with it.

Case 13. E. N. Age 13. Female. Occupation: school. Diagnosis: tuberculosis of spine. Duration, one and one-half years. Marked kyphosis, complete paralysis for two months before operation in spite of being on frame. No abscess felt. X-ray shows extensive destruction of ninth and tenth dorsal and the disc between them, with the abscess around them. Operation December 27, 1920. Beef bone splint with fusion. The splint was broken and made to overlap in order to fit the kyphos. Nine spinous processes were operated on. Convalescence uneventful. Highest postoperative temperature on the first day, 101.2. February 11, 1922: Note from the doctor says child is working around the house; general condition is excellent. She has no pain, no abscess, and she has entirely recovered from the paralysis.

Case 14. M. E. S. Age 47. Male. No occupation. Diagnosis: tuberculosis of spine, eighth and ninth dorsal, eleventh and twelfth dorsal; tuberculosis of lungs. Case reported above under "Secondary Operation."

Case 15. A. DeS. Age 33. Female. Occupation: shop. Diagnosis: tuberculosis of spine. Duration of disease, two years. Slight paraplegia seven months before operation. Abscess felt on the right side. X-ray before operation shows tenth and eleventh dorsal abnormal in

shape with obliteration of the intervertebral discs. Space between the twelfth dorsal and first lumbar also appears abnormal. Operation September 25, 1919. Beef bone splint, no fusion. Five spinous processes operated upon. Plaster shell for six weeks, jacket for six weeks more. Highest postoperative temperature 100.5. Stitches out in eight days, wound dry. Three days later, considerable discharge of blood clot. Wound dry at end of five and one-half weeks. At the end of six weeks patient was able to walk with good balance. September 26, 1921: Patient wore the brace for a year after the operation. She has had no pain in the back, but is beginning to feel very weak again. X-ray shows the beef splint present, but that it stops directly at the second lumbar and does not support the questionable pathology in this region.

CASE 16. W. T. C. Age 31. Male. No occupation. Diagnosis: tuberculosis of spine. Case reported under "Secondary Operation."

CASE 17. M. E. C. Age 45. Female. Occupation: home. Diagnosis: tuberculosis of spine. Case reported under "Secondary Operation."

CASE 18. E. S. Age 26. Male. Occupation: baker. Diagnosis: tuberculosis of spine. Two foci. Duration of disease, seven months. Some paraplegia before operation. X-ray shows disease at eleventh and twelfth dorsal and partial destruction of the third lumbar with definite evidence of abscess. Operation December 28, 1920. Two beef bone splints overlapping each other were used to take in both foci. No fusion. Spines from the eighth dorsal to the sacrum operated upon. Highest postoperative temperature 100.3. A pressure sore developed in the back due to improper postoperative care, and both beef bone splints were removed fifteen days after operation. It has been impossible to get the end-result in this case.

CASE 19. J. W. Age 47. Male. Occupation: pilot. Diagnosis: tuberculosis of spine. Duration, nine months. Some paraplegia. No abscess felt before operation. X-ray shows destructive process of seventh and eighth dorsal with involvement of the intervertebral disc. Operation May 5, 1919. Beef bone splint with fusion from fourth to eleventh dorsal. Posterior shell in six weeks. Plaster jacket. Highest postoperative temperature 100 on the second day. After twenty days a small amount of serum expressed from the wound. There was no inflammatory action. There was some pus found in the urine for two weeks after the operation. Patient returned to Nova Scotia and was not seen again, but a note dated March 27, 1922, said, "Patient is looking splendidly well and fit, and doing his work regularly as a pilot."

CASE 20. G. DiC. Age 40. Male. Occupation: laborer. Diagnosis: tuberculosis of spine, tubercular epididymitis coming on seven months after operation. Duration, seven months. No paralysis, no abscess. X-ray shows narrowing of the intervertebral disc between the first and second lumbar with slight irregularity of the body of the second lumbar. Operation January 22, 1921. Beef bone splint and fusion. Very wide gap between spinous processes bridged by a section of the spinous process. Operation from the tenth dorsal to fifth lumbar. Plaster shell for six weeks, then plaster jacket six weeks, then a brace. Convalescence uneventful. December 7, 1921: Spine in the region of the graft is completely immobilized. He has no symptoms. Has been working three months. Is still wearing the brace.

CASE 21. R. Z. Age 18. Female. No occupation. Diagnosis: tuberculosis of spine. Duration of disease, one and one-half years. No paralysis before operation, and large fluctuant abscess could be felt. X-ray before operation shows destructive process of fourth and slightly of the fifth lumbar. Operation November 16, 1920. Beef bone splint, and no fusion, from the third lumbar to the second sacral. Plaster shell for three weeks, then plaster cast and short back brace applied at the end of five months. Convalescence uneventful. February 4, 1922: Is doing lots of work around the house. She gets tired very easily and has pain in the side the same as before the operation. There has been no increase in the deformity. There is a psoas abscess, but it is not as large as before operation. No paraplegia. The operative region shows definite motion in the middle of the operative area. A definite sulcus can be felt in the spinous process. X-ray December 9, 1921, shows extensive destruction involving fourth and fifth lumbar and the disc. No positive evidence of the bone splint in this region.

CASE 22. H. S. M. Age 37. Male. Occupation: salesman. Diagnosis: tuberculosis of kidney; tuberculosis of spine. Duration of disease, one year and nine months. Slight paraplegia for three weeks. No abscess felt. X-ray September 8, 1920, showed an abscess with involvement of the fifth and sixth dorsal vertebrae. Operation December 30, 1920. Beef bone splint. No fusion. From second dorsal to seventh dorsal. Very stormy convalescence. Second day temperature to 103. On the sixth day large abscess found in the wound with discharge of pus, which gave on culture streptococcus. This abscess seemed to come from the region of the shoulder, where a kidney function test had been done a few days before the operation. From this time on, the patient was

recumbent in the plaster shell, but continued to get worse. Paraplegia became very marked, so that he had extreme jumping spasms. He died December, 1921, after a laminectomy to relieve the progressive spasticity. Operation showed tubercular abscess in the spinal canal, pressing on the cord.

CASE 23. I. M. J. Age 28. Female. Colored. Occupation: home. Diagnosis: tuberculosis of spine; acute pulmonary tuberculosis. Duration of disease, one year. No paralysis, no abscess, no temperature before operation. X-ray shows complete destruction of sixth and seventh dorsal and intervertebral discs. Operation February 25, 1921. Beef bone splint and fusion. Very stormy convalescence, temperature rising to 104 every night for six weeks. Patient died of miliary tuberculosis. Case reported under histological findings.

CASE 24. J. E. G. Age 25. Male. Occupation: soldier. Diagnosis: tuberculosis of spine. Duration of disease, indefinite. No paralysis before operation. Question of an abscess felt in the right iliac fossa. Operation April 28, 1920. Beef bone splint and fusion on one-half of the laminae from the eleventh dorsal to fourth lumbar. Plaster shell for six weeks, cast for six weeks more, and then a brace. Convalescence uneventful. November, 1921: patient is feeling fine. The operative region is solid and firm. Has been given postural exercises because of some pain in the low back region.

CASE 25. G. H. Age 25. Female. Occupation: home. Diagnosis: tuberculosis of spine. Duration four years. No paraplegia, no abscess felt. Condition at this time very acute, with extreme pain. December 22, 1920: Wedge-shape vertebra, seventh dorsal, with small abscess around it. Operation January 3, 1921. Beef bone splint with fusion of one-half the vertebra, nine spines being operated upon. Recumbency for twelve weeks and plaster jacket for thirteen months. Convalescence uneventful except for slight serous discharge. No infection in wound. February 1, 1922: Disease at seventh dorsal, inner border of the sixth and eighth are impinging, and there is slight destruction of the lower border of the sixth. The edges of the bone show some increase in density. There is no fusion of the body and the abscess can be seen and there is some increased density in this. The bone splint is present in the anteroposterior and the lateral views. There is no attempt at fusion in the diseased area. The splint is in place. Examination

shows the operative area is solid and firm and no tenderness. Patient complains of pain in the region of the ribs and of getting tired easily, although otherwise in excellent general condition. She is to be kept recumbent six months more.

CASE 27. W. G. Age 27. Female. Occupation: stenographer. Diagnosis: tuberculosis of lungs, tuberculosis of spine, tuberculosis of sternum. Duration of disease, one year. No paralysis, no abscess. X-ray before operation shows disease about tenth and eleventh dorsal with abscess. Operation October, 1917. Beef bone splint with fusion. An abscess was opened into at the time of operation which discharged tubercular pus through wound. The wound was clean and dry after operation, but on the thirty-third day it broke down, discharging tubercular pus. Beef bone splint was eventually removed. She was recumbent two and one-half years because of the spine and the tubercular sternum which later developed. February, 1922, patient is very well, working every day. Complains of no pain and the tubercular sinuses have all healed.

CASE 28. A. R. Age 22. Female. Occupation: shop. Diagnosis: tuberculosis of spine and lungs. Duration of disease one year. No paralysis, no abscess. X-ray before the operation showed destruction of cartilage between the tenth and eleventh dorsal with abscess formation. Operation August 23, 1917. Beef bone splint and no fusion. Eighth dorsal to second lumbar. Convalescence uneventful. Highest postoperative temperature 100. Patient was lost track of, but died about two years after operation from intercurrent infection. Was practically well as far as the back was concerned.

CASE 29. N. H. Age 39. Male. Occupation: carpenter. Diagnosis: tuberculosis of spine. Duration, one year. Sharp kyphos. No paralysis, no abscess felt. X-ray before operation shows eighth dorsal nearly destroyed. There is a question of involvement of the ninth, tenth, eleventh, and twelfth dorsal, which was considered to be healed. A large abscess can be seen at the eighth dorsal. February 5, 1920: Beef bone splint with fusion of one-half the laminae from sixth dorsal to first lumbar. Posterior shell for six weeks, jacket for nine weeks more, then a spring back brace. February 4, 1922, patient went to work as a carpenter three months after operation. Is still wearing his brace and is in excellent general condition. Has put on lots of weight. Has no pain and he thinks his back is straighter. Examination shows the

bridge of bone nearly an inch wide the entire length of the operative area. No motion can be made out. Considerable spasm of the lumbar muscles in the ordinary standing position, but no limitation of motion here. X-ray report February 4, 1922: The condition of bones practically the same as x-ray before operation, showing same amount of involvement. There is no definite evidence of new bone formation. The same evidence of fusion is present in the ninth, tenth, eleventh, and twelfth dorsal. The abscess is present with no sign of calcification. The bone splint cannot be made out because of interference by the ribs and sternum.

CASE 30. H. H. F. Age 16. Male. Occupation: seaman. Diagnosis: fractured spine. Duration, eight weeks. No paraplegia. Some weakness in legs. Operation May 1, 1918. Beef bone splint and fusion of one-half of the laminae from eighth dorsal to third lumbar. Convalescence uneventful. X-ray examination December 11, 1918. First lumbar vertebra was wedge-shaped. February 3, 1922: Patient has been working for two years. He never has any trouble with pain in his back. Two years ago he had some lameness in the low back below operation. Was given postural exercises which he has been doing regularly. There is no sign of paraplegia, no abscess, abdomen is negative. He is extraordinarily well-muscled and holds himself in good posture. Examination shows a broad bridge of bone an inch and one-quarter wide over the entire operative area. No tenderness or motion made out. At the lower end the splint is not in contact with the spinous process and it feels a little like cartilage at this point. X-ray February 4, 1920: Twelfth dorsal shows a slight compression. The bone splint is in place between the spines of the eleventh and twelfth dorsal. There has been a loss of continuity of the splint. The splint is slightly less dense in places than the spinous processes. There is no evidence of fusion of the vertebrae. No new bone formation in the spine. February 10, 1922: The x-ray shows the bone splint is still present. It shows definite fusion to the spines of the tenth, eleventh, and twelfth dorsal and first lumbar, and partial fusion between the second and third. The density of the splint is the same as the spinous processes. There seems to be bony overgrowth all along the region of the splint. The spinous processes of the eleventh and twelfth and first seem to be fused, and it is difficult to make out the bone splint. The splint looks as if it had been replaced by new bone.

CASE 31. F. G. L. Age 30. Male. Occupation: soldier. Diagnosis:

old fracture, scoliosis, increasing paraplegia, superficial shrapnel wounds. Duration of disease, three and three-quarters years. No abscess. No definite paraplegia, but increasing weakness. Very marked deformity. X-ray before operation showed an extensive destruction of three lower dorsal and first lumbar. Operation January 22, 1920. Very long beef bone splint with fusion on the right side. Ten spinous processes operated upon. Splint was eleven inches long. Patient died on the eighteenth day postoperative from severe scpticaemia, evidently caused by a multiple skin infection.

Case 32. J. M. Age 43. Male. Occupation: shoemaker. Diagnosis: fracture of the spine. Duration, four months. No paralysis, no abscess. X-ray before operation shows fracture of the ninth dorsal. Operation February 20, 1920. Beef bone splint and fusion of one-half of the laminae. Seven spines from the fifth to the twelfth dorsal operated upon. Posterior shell six weeks, plaster jacket. Highest postoperative temperature 100.8 on the second day. Convalescence uneventful. It has been impossible to follow this case.

Case 33. A. S. Age 17. Male. No occupation. Diagnosis: Fractured spine. Complete paraplegia, increasing deformity. Duration of disease one and one-half years. Complete paraplegia, no abscess. A laminectomy had been performed some time shortly after the accident. X-ray before operation shows marked deformity of the bodies of last three dorsal and first lumbar. January 28, 1918: Beef bone splint. The conditions found at operation were unusual because of the laminectomy previously performed. Some of the articular processes were fused but there were two places where there was no fusion. These were fused and a beef bone splint put in to bridge the gap. February 22, 1922, a letter says there has been no change in the boy's condition as regards the paralysis. He said he was all right from the knees up and complained of no pain in the abdomen such as he had before the operation.

Case 34. M. C. Age 37. Female. Occupation: home. Diagnosis: infantile paralysis. Duration, two years. Complete paralysis from the waist down. Complaint: inability to wear a brace, and marked pain in the lumbo-sacral region. December 8, 1917: The beef bone splint with fusion was done from the third lumbar to the third sacral vertebra. The highest postoperative temperature was 100 the first day. Convalescence uneventful. About a year later an arthrodesis according to the Smith-Petersen method was done on the sacroiliac joint. February 25, 1919: X-ray shows the splint in place extending from sacrum

to third lumbar spinous process. It is in contact with the spinous processes, but shows no evidence of fusion with them. The splint is of the same density as the surrounding bone. February 14, 1922: The bone splint is still present, but is not as definitely seen as two years ago. The two cortical layers seem a trifle broader and the cancellous layer somewhat less broad than at previous note. That part of the splint between the third and fourth lumbar spine is seen with difficulty. Final examination February 14, 1922, shows patient in excellent condition. There is a broad ridge of bone extending from sacrum to the third lumbar. Patient can sit up without her jacket, but wears the leather jacket most of the time, having little or no pain in the back. There has been a very definite return of muscle power in both gluteal muscles.

DISCUSSION OF DR. BROWN'S PAPER.

Dr. Fred H. Albee, New York: I am very sorry Dr. Brown did not include the autogenous graft in his experimental work, especially since the purpose of his paper was apparently to prove the relative value of the living autogenous graft, the boiled bone splint, and the fusion operation of Hibbs. Boiled bone acts as a foreign body in its tolerance to the tissues. In Dr. Brown's series of 24 cases, to my mind, the fact that three of the boiled bone splints came out is proof that it is much less tolerant than the living autogenous graft. It is a foreign body; it is not living tissue. Back in 1910, at the Cornell Animal Hospital, I did a considerable number of these experiments and published a few of them. Operations to immobilize the dog's spine with living bone taken from the same dog, from sheep, from rabbits, and with boiled bone were done. The findings were quite striking between, for instance, the heterogeneous graft taken from the sheep and that taken from the dog, the autogenous graft. We found that where there was no infection, the autogenous graft could be healed in a very short period, a week or two weeks, by primary union. There would be primary union of the soft parts to the graft precisely as we get a primary healing of a soft wound. It was quite different with the heterogeneous graft or sheep's graft, which always lay in a pocket of serum. There was a liquefying action set up by contact of heterogeneous tissues. There was no primary union of the graft to the soft parts. The same condition occurred when boiled bone was used. Dead bone lowers the resistance of the tissues to infection precisely as does any foreign body. Certainly the dangers from putting in foreign bodies are greater as far as infection goes than a living graft.

Now as to the disadvantages of the boiled bone splint. Of course, boiled bone was used a number of years ago, some ten or fifteen years, by the Germans. There is quite a little literature giving experiences with it; in fact, in the first book I wrote upon bone grafting I enumerated the German table of the relative values placed upon the various internal splints. I have had this experience many times in which we would have the end of the living autogenous graft laid bare by sloughing of the skin with only a corner of the graft sequestrating. I am sure that many of you who have done bone grafting know that if you have a mild infection the infection may remain at the end of the graft where it occurs in the way of a stitch abscess and never

disturb the main portion of it. If you are using a foreign body, such as ivory or boiled bone, infection occurring at one end will always travel to the other end of the splint and it must all come out. I remember one graft which I put in for non-union of the olecranon becoming entirely bare by slough of the soft parts, much to my surprise at the time, ten years ago, it healed so completely and an excellent result obtained. Though it may stay in for six months or a year or longer, it is always a devitalizing influence to the host tissues surrounding it, and there is always danger of infection occurring about it because of *locus minoris resistentia*. I would like to mention in passing a modification of my technic of implanting a graft for Pott's disease, which I borrowed from Forbes, and he, perhaps, in turn borrowed from Hibbs, of turning down bone shavings from the upper and inferior surfaces of the spinous processes so that we have the effect of the bone tibial graft besides the internal immobilization and additional osteogenetic foci of the bone shavings.

Now to take up Dr. Brown's objections to the autogenous graft: First, he says there is the saving of time in the operation if boiled bone is used instead of the living autogenous graft. How much time do you save in the operation? In favorable cases I am sure that I can demonstrate to anyone who comes to my clinic the ability to do this operation in twenty minutes. How much of that time is consumed in taking out the graft? Perhaps five minutes. Next, the saving of an extra incision. I do not see that saving of that extra incision is any advantage. We find that the two incisions heal as quickly as one. Third, lack of pain in the second incision. That is certainly of no moment and I am sure will be borne out by men who have done bone graft work. Fourth, the possibility of preparing the bone splint before operation and the time thus saved at the operating table. Of course, the time of preparation of the graft at operation is so short that it is of no moment. In regard to strength of the graft, if one cuts the graft so that the greatest cross-section comes at the fulcrum of the graft one gets a very strong splint. Of course, it is very necessary and obvious that the fulcrum point of the graft, its central portion, should come at the crest of the tibia. Then the question of the possibility of getting a sufficiently long splint. If this operation is done when it ought to be, there is no trouble about getting a sufficiently long tibial graft. In the cases which Dr. Brown showed where he put in those tremendously long splints involving four healthy vertebrae on either side of the diseased ones, I believe it not only unnecessary but unwise to put in such a long splint.

Now as to the beneficial influence of recumbency: If there is any value in recumbency in the treatment of hemiplegia complicating Pott's disease, we get the same effect to a greater degree in ankylosis of the involved portion of the spine.

THE PATHOLOGY OF OSTEITIS DEFORMANS, PAGET'S DISEASE.

BY SYDNEY M. CONE, A.B., M.D., F.A.C.S., BALTIMORE.

[From the Pathological Laboratory of the University of Maryland.]

OSTEITIS DEFORMANS as a disease entity was first described by Sir James Paget, under the title "On a Form of Chronic Inflammation of Bones (Osteitis Deformans)", in the *Medical Chirurgical Transactions* (London), Volume lx, 1896, page 37. Since then many typical cases have been described and the original photographs published. Much has been written of atypical cases, such as Paget's disease of single bones, Paget's disease involving only the face bones, and Paget's disease involving the small bones (phalanges of fingers). The disease has been related to osteomalacia, senile rickets, neurotrophic bone lesions, fibrous osteitis, leontiasis ossea, acromegaly, pulmonary osteoarthropathy, syphilis inherited or acquired, senile osteoporosis, bone hypertrophy, hyperostosis in elephantiasis and from other causes, traumatism, osteomyelitis, hydrocephalus, chronic rheumatism, and arthritis deformans. Some have suggested its relation to an infectious process, whether typhoid, syphilis, malaria, or influenza. Few have studied the bones and fewer have studied the bones, organs, and tissues.

It has been my good fortune to study the bones, tissues, and organs of a case which has already been perfectly written up clinically and published. The case is the first of six described by Hurwitz in the *Johns Hopkins Bulletin* (Volume xxiv, No. 261, page 263, September, 1913). The patient, J. P., age 85, had been attended by Dr. Lockard of the University of Maryland at various times since 1905. He admitted the patient to his clinic in August, 1920, complaining of frequent micturition with burning and stinging, and hematuria. Patient also had protruding hemorrhoids. He had enlarged skull, kyphosis, contracted chest, flaring of upper pelvic brim, bowed femora and tibia, rough, nodular, curved clavicles and radii,—a typical picture of Paget's osteitis deformans. He died December 1, 1920, when an autopsy was performed by Dr. Maldeis. Unfortunately neither the pituitary gland nor skull bones could be obtained.

The protocol of the autopsy has been kindly given me by Professor Hugh Spencer, to whom I am most thankful. To Dr. William Carson I am much indebted for taking the photographs and making lantern slides of the pathological specimens.

Name: J. P.

Location: Ward H, No. 21.

Date of admission: August 22, 1920.

Date of death: December 1, 1920.

Autopsy performed: December 1, 1920.

Clinical diagnosis: Paget's disease.

Body is that of a very much emaciated white male. Rigor mortis and post-mortem lividity present.

Head: Enlarged.

Eyes: Pupils are contracted, but equal.

Nose and ears: Normal.

Mouth: Both upper and lower set of teeth missing.

Neck: No glandular enlargement.

Chest: Clavicles are both thickened and deformed, more marked on the right side. Chest is flattened in its lateral diameter, bulging in the lower portion, somewhat elongated. Axillary glands not palpable.

Abdomen: Is flattened.

Left radius: Is bent considerably; bowing of the tibiae. Surface veins are prominent all over body. Inguinal glands are palpable. Very small amount of subcutaneous fat, and poorly developed muscles. Kyphosis of the upper dorsal vertebrae.

Peritoneal cavity: No free fluid; no evidence of inflammation. General gastro-enteroptosis. Transverse colon is below the umbilicus. Liver is 9 cm. below the ensiform cartilage. Gall-bladder is distended. Vessels of the omentum are engorged. Appendix is short, firm to the touch, and tortuous; no adhesions, postcaecal in direction. Bladder is slightly distended. Diaphragm in normal position.

Thoracic cavity: Is free of fluid on both sides. Adhesions on both sides, more marked on the left. The heart is normal in position. Lungs on both sides are retracted from midline, exposing the whole of the pericardial surface. Pericardial sac contains about 40 c.c. of blood-tinged fluid. Heart lies free. The heart, thoracic and abdominal aorta with branches were removed *en masse.*

Heart: Is firm to the touch; the vessels at the base are very thick

and firm. The right auricle shows nothing of interest. Right ventricle—Endocardium is shining and glistening everywhere. Tricuspid and pulmonary valves show nothing of interest. Left auricle shows nothing of interest. Left ventricle—There are a few post-mortem clots; chordae tendinae are hypertrophied and shortened. Mitral valve is thickened along its free edge and contains lime deposits. Aortic valve—Leaflets are irregular, shortened, and somewhat thickened; contains lime deposits. Both coronaries are tortuous and show sclerotic changes and lime deposits; lumen still patent. Musculature of the heart is light red in color and shows an increase in connective tissue.

Aorta: The ascending arch is somewhat dilated, not abnormally so. The wall of the arch is atheromatous and there is an area of softness and a marked prominence on the posterior wall which is covered over with a bloody material showing organization. This area was observed only after stripping the pulmonary vessels from the aorta; it was apparently well enclosed. The entire aorta shows atheromatous degeneration in various stages of development; the lower portion, including the branches, shows marked advanced arteriosclerosis.

Right Lung: Adhesions on the right side are extensive, practically obliterating the cavity, and they can be broken up only with some difficulty. It is air-containing throughout, being less so in the lower lobe. The pleura is thick and dull. Bronchi and divisions show a moderate amount of bloody fluid. Pulmonary vessels show nothing of interest.

On section the apex shows an old, healed, encapsulated tubercle; the rest of this lobe and middle lobe is of a light red color, and blood-tinged, frothy fluid scrapes off. The lower lobe is dark red, drips blood, and there are a few well-defined, light-colored, granular, partly consolidated areas. The border of the lung is emphysematous.

Left Lung: The pleura has a few fairly well organized tags. It is air-containing throug' out, but less so at the base. The hilic structures and sections show the same changes as the right, with the exception that there are no tubercles present.

Larynx and trachea and other mediastinal structures show nothing of interest. The glands are hypertrophied, firm to the touch, anthracotic in appearance.

Liver: Weight 350 grams. The wall of the gall-bladder is thin, bile is ropy and thick and black, and there are a few small stones present. The ducts are patent. The liver cuts with little resistance; the central

vessels of the lobules are slightly engorged; periphery is increased and whitish in appearance.

Spleen: Weight 130 grams. Capsule is very much thickened. On section there is a marked increase in connective tissue elements. The organ is very firm, dark red in color; corpuscles stand out plainly.

Kidneys: Together weigh 364 grams. Both kidneys show the same changes. The capsule strips with difficulty, leaving a granular, slightly pitted, red surface containing a small cyst. The cortex is very irregular in outline, striations cannot be made out. Glomeruli are indistinct. Medulla is irregular, pyramids are not well defined, and there is slight congestion in this area. Pelvis contains an excess of fat; otherwise negative. Ureters show nothing of interest.

Bladder: Contains a stone the size of an English walnut, and there is a papillomatous growth at the base; the mucosa is markedly congested and very angry looking, and covered with a mucous material. The ureteral orifices are patent and show considerable inflammation about them.

Prostate: Is slightly hypertrophied and shows an increase in connective tissue elements.

Suprarenals: Are firm and show fibrous changes at the cortex.

Oesophagus: Shows nothing of interest.

Stomach and Duodenum: Stomach shows a congested mucosa and petechial hemorrhages; is rather small. Duodenum shows nothing of interest.

Pancreas: Lobulations well marked; slight congestion, and there is a stone in the pancreatic duct. Marked sclerosis of the pancreatic vessels.

Small and large intestines show nothing of interest.

ANATOMICAL DIAGNOSIS: Osteitis deformans (Paget's disease). Generalized arteriosclerosis in all stages of development. Arch of the aorta shows an ulcerated type with an overlying blood clot.

Lungs: Bilateral chronic pleurisy; oedema and congestion, and patches of bronchial pneumonia at the bases.

Heart: Chronic changes in the mitral and aortic valves, with lime deposits; sclerosis of both coronaries; fibrosis of the myocardium. Nuclei enlarged and budding. Brown pigmentation. Vessels arteriosclerotic.

Liver: Chronic passive congestion.

Spleen: Chronic passive congestion. Hyaline degeneration of vessel walls and trabeculae.

Kidneys: Chronic interstitial nephritis and arteriosclerotic changes; congestion and hemorrhage into the tubules.

Bladder: Acute cystitis with stone and tumor mass, the size of a marble, on a pedicle.

Prostate: Interstitial hypertrophy.

Suprarenals: Chronic changes. Arteriosclerosis; calcification of media; muscle and veins hyperplastic.

Stomach: Congestion and petechial hemorrhages.

Pancreas: Chronic changes and stone in the pancreatic duct.

Enlargement of the bony skeleton, with irregularities in the shape.

Heart: Hypertrophied and fibrous.

Aorta: Arteriosclerosis.

Lungs: Oedema; congestion; broncho-pneumonia; chronic pleurisy.

Liver: Chronic passive congestion.

Pancreas: Chronic changes.

Suprarenals: Chronic changes.

Spleen: Passive congestion; chronic splenitis.

Prostate: Chronic interstitial hyperplasia.

Kidneys: Chronic parenchymatous nephritis.

The bones removed for pathological examination are: vertebra, rib, clavicle, radius, tibia.

The tibia is 45 cm. long and 4.5 cm. in diameter. It is bowed forward and there is a projection backward of its head of about 1.5 cm. Its surface is smooth. The periosteum strips readily, not tearing bone with it; periosteum not thickened. No nodules seen, but bone is not perfectly smooth.

Section shows a thickening of the cortical portion of the tibia. The cortex at the middle of the bone measures 2.5 cm. at its anterior portion; the posterior portion measures 1.5 cm. Its cortical thickening is dense bone, irregular in its formation toward the medulla, where it projects in parts, particularly at the middle of the bone, into the marrow cavity. Here, at one point, there is no marrow cavity left. The marrow is yellow, fatty, and contains spongy trabeculae throughout its extent. It is congested at the middle of the bone where the cortical bone is thickest. At this point there is a thinning of the bone on the concave side of the tibia to ¼ inch, and it is jagged and irregular at the marrow substance. Here and there in the dense bone are seen

widened canals surrounded by deep brown pigmentation. At the posterior projecting portion of the head four intercommunicating empty cysts are seen in the medulla, ½ cm. to 1.5 cm. in diameter. Walls 2 mm. in thickness and firm, containing a few trabeculae or spicules of bony substance. The surrounding marrow is unusually porotic and toward the periosteum is deeply congested. There is no eburnation at this point. The articular surface of the bone is perfectly smooth.

The radius measures 9½ inches in length and averages ½ inch in width. It is thickest at the bicipital tuberosity, where it measures 1 inch in diameter. It is curved acutely backward at the middle. The periosteum strips readily, leaving a granular surface. There is no apparent new periosteal growth. The cortex is dense, eburnated bone, for the greater part, encroaching on the marrow at the middle of the bone for 3 inches of its extent, so that no marrow is seen at the lower third of the bone. The marrow cavity at other points measures 6 mm. in diameter, the upper portion being hemorrhagic, the lower portion yellow and fatty. The lower epiphysis is congested. The thickening on a level with the bicipital tuberosity is denser at the posterior portion of the bone. The part immediately under the attachment of the biceps, although being eburnated bone, contains some fine porotic bone. The attachment of the biceps strips away with difficulty, leaving a rough, moth-eaten appearing bone beneath. The rest of the surface of the bone is smooth. The articulating surfaces are normal and no evidence of new periosteal bone is seen.

Clavicle: The clavicle is S-shaped in form, there being an acute anterior bowing 2 inches from its sternal end, the posterior bowing less acute toward the humerus. The bone originally should have been 7 inches long. The clavicle is 6½ inches in length and varies much in thickness. The innermost end up to the middle measures 2 cm. Here the bone gradually thickens until at the outer end it is 2.5 cm. in diameter. There is no marrow cavity left, but a wider meshing of the bone is noted at the middle, where it is congested. The acromial end is quite granular and more or less frangible, and not so dense as the other extremity. There is an irregular mottling of brown color at this end. The surface is finely granular and the periosteum strips off with a little difficulty. Elsewhere the periosteum strips readily, leaving a smooth surface beneath. Congested points more or less depressed are seen throughout this sub-periosteal bone (position of nutrient vessels). Similar points were seen here and there on the other bones. The sternal end is smooth. The cartilage is congested and almost

entirely gone at the acromial end, being as thin as a sheet of paper, but not quite eroded through.

Rib (a portion of the rib retained for examination): This rib measures a little more than 4 mm. in thickness, 2.5 cm. in width, and is very thin, being very much thinner, as if drawn out, at its upper border. There is no evidence of eburnation. The marrow is red, except at the sternal border, where it is only slightly pigmented. The sternal end of the cartilage has become ossified for the greater part. The periosteum strips readily, leaving porous bone beneath. In places there is a mere shell of cortex left. The upper extremity, however, shows a condensation of bone, and here tissues cannot be easily stripped from the bone. There are large openings here and there for nutrient vessels.

Vertebra: This specimen consists of one-half of adjoining vertebra ankylosed together. The substance of the spongy bone remains attached at the ankylosed point, showing the intermediate cartilage, which is in most part fibrosed, but at the contact with the spongy bone of the vertebra it is quite irregular and congested. At one point the vertebra spongiosa is very hemorrhagic, very porotic, and at its junction with the cartilage breaks away in nodular pieces, leaving smooth, glistening cupped areas behind. Here and there pieces of eburnated bony structure remain behind. These are rounded and nodular. The other vertebra shows a similar condition but is not nearly so congested. The surrounding ligaments tear away, pulling spongy congested bone with them. There is no evidence of new bone formation on the surface of the bone.

Nutrient Vessels of the Tibia: The nutrient artery removed from the nutrient canal of the tibia measures 4 mm. in diameter; it is thin, irregular in shape, glistening and soft. Its lumen is smooth and blood-stained.

All the bones can be sectioned with a scalpel. The rib is the softest.

MICROSCOPIC EXAMINATION OF FREE-HAND AND DECALCIFIED MICROTOME CUT SECTIONS.

Stains: Hematoxylin and eosin, carbol-fuchsin, alum carmin, Wright's, polychrome, methylene blue, and Gram's stain.

Tibia: The structure of the bone is erratic, consisting of abruptly ending trabeculae abutting against circumferential or interstitial lamellae of old bone. Between larger cancelli are included small pieces of bone looking like worn-down trabeculae. The points of con-

tact are always irregular, as if lacunar absorption had taken place and was recovered by new formation of bone or by crushing in of old absorbing bone. In some of these trabeculae there are ten to fifteen lamellae laid down. Where they come in contact with the Haversian canals they frequently show finely granular structure, faintly eosin-stained. Again, they are infrequently lined by a homogeneous eosin-stained lamella of new osteoid tissue. The lacunae as a rule are well formed in the interior of these cancelli of bone, but some of them are very big, bordered by an eosin-stained granular material, outside of which is seen a hematoxylin-stained granular border (see photo). In many of these lacunae, especially those bordering the canals and spaces, there are two or three nuclei and cells.

The marrow is myxomatous, with varicose capillaries, some of which are degenerate. There is very little fat in the spaces. The canal system is quite erratic, being made up of irregularly branching wide and narrow lines and broad spaces. Their borders are usually rough; some are smooth. Within them are seen very thin-walled vessels congested with blood. There are many new-formed capillaries in loosely meshed myxomatous tissue. It is not so fibrillar as that in the canals of the clavicle. The bone in the upper extremity of the tibia is extremely porous and spongy, yellowish in color, and consists of a meshwork of irregularly running trabeculae, many of them being moth-eaten in appearance. There is considerable fat and myxomatous tissue in this spongy bone which surrounds the multilocular cysts described macroscopically. The cyst walls vary in thickness and consist in the main of hyaline connective tissue with elongated nuclei. Here and there are seen eosin-stained bone spicules in the fat marrow. Forming cysts are seen as spaces, measuring 20 to 60 mm. in diameter, with a thin hyaline wall 10 mm. wide. A deeply eosin-stained oval or rounded mass is in the center. A few oval cells like bone cells lie within the spaces and in the connective tissue about them. These cells contain unstained circular spaces—possibly fat droplets. I take these to be bone cells. They are seen throughout all of the bones. The vessels about the cyst wall are degenerate and irregular in shape. The periosteum is not thickened over the tibia. The bone has a porotic, moth-eaten appearance at the surface, where it takes a deeper hematoxylin stain and is granular. Much brown pigment in cells and stroma. All cells of the articular cartilage are multiplying actively. The most evident proliferation is next to the bone. Here the cells and capsule

spaces contain much blood pigment. Many capsules are enlarged and broken.

Bone from the Bicipital Tubercle of the Radius: This resembles bone from the vertebra and clavicle, the erratic texture being most marked in the blunt ending of trabeculae and their moth-eaten appearance, the old Howship's lacunae having been covered over by new formation of bone. The spaces of the medulla are less marked here than in other parts of the bone, and there is a transition of the attachment of the biceps into a metaplastic bone, the tendon and muscle having become ossified. There is a transition of trabeculae through fibrous tissue to myxomatous tissue.

There are osteoblasts in rows on osteoid tissue covering and filling Howship's lacunae. There are areas where the newer bone has been softened, breaking up again into softened granular bone covered by polygonal cells.

The marrow is cellular and myxomatous. The vessels are small but varicose (irregularly dilated). Fragments of bone are seen in the marrow. Remnants of disappearing swollen lacunae with multiplying bone cells adjoin that portion of the bone next to the marrow. Here we see many remnants of bone cells in the shape of free oval nuclei. The bone and marrow are both pigmented with broken-down blood pigment. The main shaft of the radius resembles the clavicle in its structure. The bone contains much pigment.

Clavicle: The clavicle cuts fairly easily. It is granular in appearance and is made up of trabeculae which end abruptly, meeting cancelli coming from other directions, the line of contact being rough, as if it were the seat of old erosion. This border is hematoxylin-stained. There are no normal trabeculae; they are short, turned, and twisted. Many show lacunar absorption. The canals are widened and contain a fibrillar connective tissue with tortuous varicose vessels. These are lined by a single layer, broken here and there. Red blood-cells are seen in the surrounding tissue. Some canals contain groups of round and polygonal cells, some still lying in macerated granular bone tissue. Giant cells (osteoclasts) are seen here and there in grooves. Oval, round, polygonal and stellate cells are seen in transition. Free oval nuclei are in granular bone and marrow. The lacunae adjacent to the canals are enlarged, as are the bone cells within them. There are two nuclei in many of these cells. The contents of the canals in the main are of fibro-myxomatous tissue. There are a few osteoblasts and

they are elongated, flat against trabeculae. The bone absorption is the main process, and that appears to be by softening and metaplasia, and partly lacunar. There are no good vessels anywhere and there is less fat than usual. Many new-formed, irregularly swollen capillaries branch through the myxomatous tissue. There are many free red blood-cells and some normoblasts.

The bone and marrow are pigmented with blood. There are some areas of osteoid tissue covering the trabeculae of bone. There appear to be remnants of old bone, with its regular circumferential and Haversian lamellae caught in between the irregular formation of bone, the bone cells of old bone being smaller and more regularly parallel in arrangement. Those of the new bone are irregularly placed and not at all systematically parallel, and the cells and lacunae are larger than in the old bone. Some few of the old Howship's lacunae of absorbing bone are overlaid by a new bone layer outlined by a distinct, irregular, hematoxylin-stained, calcified line. A few trabeculae are lined by flat osteoblasts, but there is no evidence of recent functioning. (There is more osteoid in this bone than in others.) The periosteum is not thickened. The bone beneath it, however, is rough, due to lacunar absorption of old bone, and there are vertical clefts in the bony structure, filled with myxomatous tissue such as is found within the canals. Here irregular pieces of eroded bone, continuous with old bone, project into periosteum, and bone débris is seen elsewhere in periosteum. There are a few areas of polygonal cells where the bone is granular, showing a transition to stellate and longitudinal myxomatous cells. Free homogeneously stained nuclei, some containing vacuoles, are among them. Bone spicules are seen in the marrow spaces and canals, some of them lying between newly formed capillaries. The vessels appear as gaping, tortuous, and thin-walled, or as compressed fibrous bands. Many have hyaline walls; some are plugged with hyaline and granular thrombi. One larger vessel, a longitudinal canal, is in great part calcified.

In the articular cartilages are actively multiplying cartilage cells in oval and irregular spaces. There are areas of transformation into myxomatous and fibrous strands. In the area of greater softening next to bone are seen irregular lines of eroded bone. Calcification of the bone is evenly spread.

Rib: The rib is very thin, pointed at its lower border and blunt at its upper border. It is spongy in structure, with no well-defined

marrow cavity. The surface is rough. The periosteum strips readily. The periosteum is not thickened, but there is evidence of hyperplasia of adjacent and contained structures; the vessel walls are thickened; the nerves are hyperplastic, contain great numbers of Schwann sheath cells, and the perineurium is thickened; the muscle contains great numbers of nuclei, which are arranged, as a rule, in long lines, many of the nuclei being apparently confluent (see photo). There are in places clefts through the cortex adjoining the periosteum in which bone marrow is seen. These clefts seem continuous with vessels of the periosteum, several of which are full of bone marrow, possibly evidence of old bone which has been left behind in a bone-absorbing process. The main mass of the rib consists of trabeculae of spongy bone, most of which are very thin (20 to 30 mm.) and irregular in width, eroded by lacunar absorption. Some of them show strands of fibrous tissue as if reverting to their original condition. There is blood pigment in bone spaces, lacunae, and stroma.

Calcification is regular and evenly spread. The canals are most erratic in dimension and the course which they take, and are full of very cellular marrow. The cells of this marrow are as a rule large (15 mm. in size) where they adjoin the cancelli. They are frequently noted as polygonal in shape and in layers six deep. There is an unusual evidence of lacunar absorption, giant cells and old bone cells filling many of these Howship's lacunae and larger depressions in the bone. The vessels are small, numerous, and congested with blood. Only here and there can be seen any evidence of new formation of bone, and this is as a layer of osteoid filling the grooves on the trabeculae. At the lower border, where the rib has been narrowed and apparently drawn out to a point at the attachment of the intercostal muscles, there has been a metaplasia of soft parts into new-formed bone. A deeply hematoxylin-stained area adjoins the muscle attachment. A border of eosin-stained new osteoid bone with bone cells adjoins the above described porotic bone of the rib proper toward the interior. The upper border is rounded and shows evidences of osteoporosis. Canals from the bone proper are seen in the surrounding tissue. The vessels in the marrow at this point are degenerate, the media being particularly involved. At a point on the flat surface a widened canal filled with cellular marrow penetrates to the periosteum, and a linear longitudinal cleft filled with marrow cells lies between a trabecula and periosteum. A tortuous vein, 10 to 60 mm. in size, is alongside, between periosteum and

muscle. This is packed with such cells as are seen in the bone spaces. Many bone spicules are in tendon attachments. (This is evidence of bone absorption at the periosteal attachment.) Some of the trabeculae show evidences of edema, their lamellae are widened, and granular and bone lacunae with cells are enlarged. Here there is seen a transition from fibrous to cellular myxomatous tissue. The predominating cell is large (15 mm.) and polygonal. At one area there are so many of these larger polygonal and round cells in contact with eroded bone trabeculae that one must think of sarcoma. This was, however, seen only once in the many sections cut from all parts of the rib.

Vertebra: The structure is erratic, like that of the radius, clavicle, and tibia, but in the main the bone resembles the rib in its more cancellous structure and cellular marrow. Where the bone cancelli and plates are adjacent to the cartilage there are numerous wide coalescing lacunae and Howship's lacunae. That side of the cancellus of the bone next to the cartilage has been absorbed, until in some cases the Haversian canal with its contained marrow is in contact with the cartilage. The cartilage is calcified and fibrous; its cells have multiplied. The marrow is like that of the rib, but contains more small, round cells, normoblasts, débris, and fragments of bone. There is a mixture of dense masses of large and small round cells, some Heidenhain's giant cells and normoblasts. The vessels are numerous, thin-walled, irregular, bulging, and full of blood. There is free blood in the marrow, and loose, stained, stringy material (mucus) in parts of the marrow. There are areas of marrow which do not take the stain. These are necrotic foci. The bone cells, marrow, and lamellae are pigmented with blood pigment. The vessel degeneration is as marked as in the rib. Thrombosis and congestion are marked. Areas of necrosis in marrow cells are evidenced by the granular condition and lack of staining, accompanied by minute fragments of bone.

RÉSUMÉ OF THE PATHOLOGICAL FINDINGS.

It will be seen that the organs are the seat of arteriosclerosis, the media of the vessels being mainly involved, except in case of the aorta, which is covered with atheromatous plaques. The heart vessels are not much involved; the heart muscle itself shows brown pigmentation and enlarged, budding, increasing nuclei. The liver cells are pigmented; many nuclei very large and budding, and the organ is remarkably well preserved for such an old man. The kidney is the seat of irregular arteriosclerosis.

Some glomeruli are hyaline, others congested; there is hemorrhage into the tubules, which show a little parenchymatous degeneration, and the epithelium is still actively regenerative. The tubules which are dilated are lined by densely overgrown cuboidal epithelium with deeply stained large nuclei. The spleen is deeply congested and its capsule is very thick, containing a dense line of pigment next to the dense splenic substance. (Photo 19). Some of its larger vessels are bulged laterally by fibrous nodules in the media. The suprarenal shows a hyperplasia of the muscle elements of the medullary vessels and increase in ganglion cells. Some of its vessels have a calcified media. The lymph glands are very deeply pigmented (brown) and contain areas of hyaline fibrous nodules; there is no longer remaining a differentiation into its normal architecture. It is remarkable that with all the vascular changes we get such proliferation of muscle and epithelium. The bone changes vary in the different bones and in varying parts of the same bone, apparently due to changed static and circulatory conditions. These differences were noted macroscopically as well as microscopically. The vessel changes are most remarkable, and vary in amount in different bones and in the same bone. Degeneration is out of all proportion to similar changes elsewhere in the body. The nutrient vessels and degenerate vessels in the marrow are pictured (photo). The newly formed capillaries and small veins are distorted, varicose, and broken, and there are areas of hemorrhage and pigmentation.

Many vessels are occluded by hyaline or vascular thrombi. Some appear ossified, others fibrosed and incorporated in the newly formed bone.

The erratic formation of bone is remarkable. Bone absorption is going on both by lacunar absorption and by fluids (Von Recklinghausen calls it by vital fluid absorption as in osteomalacia). The new formation had evidently ceased for the greater part; evidently the new lamellar arrangements had occurred in by gone years by absorption and possible crushing of the modified bone. There are a few new osteoid deposits, however, covering the Howship's lacunae and lining trabeculae of older bone. There is no evident new bone formed from the periosteum in our case—maybe there had been long ago. One of the characteristic features is new formation and disappearance of new bone. One sees a granular condition of such bone with widened lacunae and enlarged *multiplying bone cells* in bone lining the canals. Many trabeculae gradually fade away at their ends where either fibrous bone and granular eosin stained material or polygonal and stellate cells are seen. Here, too, bone cells lie

free in finely granular bone and in adjacent spaces (See Bast and Haour). These large polygonal and round cells are most numerous in the bones which contain young (embryonal) marrow. I will refer to them again as seen so often by me in cases where vascular congestion with edema occurs in leukemic marrow next to softened bone and in osteoid tissue. Red blood-cells, normoblasts, large and small round cells, Heidenhain's giant cells and ordinary osteoclasts are seen. The marrow of clavicle and tibia is replaced by fibrous and myxomatous tissue. The rough surface of the bones is due to absorption as in the vertebra next the cartilage, in the rib next to the periosteum and at the radius tubercle (See photos). Haversian canals adjoin or have been left in adjacent tissues. I cannot explain the marrow-filled vessels in the tissues adjoining the rib and tibia in any other way.

The bone spicules not infrequently lie free or in the connective tissue of the marrow cavities. In one case a spicule is pictured lying between two degenerating capillaries. In the cyst walls of the tibia, spicules are present, and forming cysts contain degenerate pieces of bone. There is no normal marrow space—all canals and spaces run together and contain the same kind of material in corresponding parts of the bone. The widening of canals and spaces has its prototype in the individual bone lacunae, the Virchow bone territory about the lacunae, then a coalescing of these dissolved territories and lacunae to the larger canals and clefts. The lamellae of bone next to canals are frequently swollen and sometimes replaced by a linear network—fibrous bone in a metaplasia to myxomatous tissue.

In the vertebra alone are seen evidences of complete cutting off of nutrition by thrombosis. Here are areas of unstained necrotic cells and bone. The cartilages of radius and clavicle are thinned by metaplasia through fibro cartilage to myxomatous tissue. The vertebral cartilage is otherwise modified. In one place it is fibrous, in another there is calcification about multiplied cartilage cells, and nearby is seen a line of calcification where the lamellae of adjacent bone have disappeared. Calcification as a general rule is evenly spread. Only in those areas where absorption seems to be in an active stage one sees irregular splotches of granular hematoxylin or fuchsin-stained calcium next to a clear zone (see radius tubercle, photo 13).

The vessels throughout are bad—thin walled, varicose, sclerotic, calcified or thrombosed.

The nerves in periosteum and in muscle are hyperplastic. The Schwann

sheath cells are quite prolific and a dense *fibrous perineurium* ensheathes them. (Photo 17).

The muscle adjacent to all bones contains great numbers of nuclei. These are arranged in rows or are discrete. In some fibers the rows are so densely packed as to make it impossible to distinguish a single nucleus. They have a remote resemblance to the nuclear arrangement in young tendon. (Photo 18).

A similar nuclear multiplication is seen in other muscles of the body, but it is not so marked as in those attached to the ribs and vertebrae. The second case is of a very different type and should not be classed clinically with Paget's disease of the bones, but its pathology is like that of osteitis deformans. Czerny's original observation on osteitis deformans affecting single bones having been published in 1873, was referred to in Sir James Paget's original publication. Since the pathology corresponds exactly to the findings when many bones are involved and since it brings closer together the relationship between leontiasis ossea and local hyperostosis with osteoporosis, I include it here.

J. H. M., Male, age 64, came under my observation first in 1911, complaining of pain in and bowing of his right femur. He had pain in the back and joints, frontal and occipital headaches, but was otherwise well. No heart disease or vascular disease. He had typhoid fever and spinal meningitis at 17 years and suffered frequent attacks of malaria. He was shot in the upper right thigh when 20 years old, being laid up a long time. The bone was not fractured.

There is forward and outward bending with thickening of the upper third of the femur. No other bones involved. X-rays were made at the Johns Hopkins Hospital and in the Hebrew Hospital. Dr. Baetjer reports in May, 1913: coxa vara and Paget's disease of the femur and calcification of the pituitary gland; tibia negative; sella turcica normal; skeleton normal.

Last year patient had edema of right limb, with great pain and swelling at site of bending of his femur, due to phlebitis.

The femur has remained normal for ten years and his pains have disappeared excepting the frontal and occipital headaches.

Among clinical manifestations noted by various authors who have seen the bones of osteitis deformans, are valvular heart lesions, arteriosclerosis, pain, headaches, retinal hemorrhage, mania, neuritis, brittle hair, body pigmentation, scleroderma of spinal cord and brain symptoms, sarcoma and carcinoma of bones.

In Sir James Paget's descriptions, there were innumerable apertures for vessels, the whole outer skull being finely porous. All channels were enlarged. The grooves for vessels were much deepened. There was irregularity of density—the bone being both porous and like limestone. The periosteum was not visibly changed, not thicker or more adherent than usual. The outer surface of the walls of the bones was irregularly and finely nodular as in the case of deposits or outgrowths of bone. There was a greatly increased quantity of blood in the vessels of the bone. The medullary structure appeared as little changed to the naked eye as did the periosteum. The marrow appeared soft, yellow, ruddy, and bright crimson. The lacunae and cancelli had a normal aspect and arrangement. The compact bone was everywhere much thickened. There were areas looking as if the outer layers were separated. The walls looked like fine coral. The cancellous spaces were encroached on by new bone.

Mr. Butlin described the microscopic structure from the skull and tibia. The number of Haversian canals and systems in any given section was much diminished between the canals. The ordinary bone substance had numerous lacunae and canaliculi. The Haversian canals were enormously widened and confluent. In them was a large quantity of ill developed tissue and blood-vessels, leucocytes, fibres or fibrocells, few myeloid cells; fat too, especially in the skull. The vessels were small (normal) compared to the spaces. Some canals were lined by osteoblasts in a single layer like an ossifying membrane.

New bone was most evident in the periosteum of the tibia external to the compacta, but was much less developed than the cortex *from which it sprung*. There was no such similar finding along the marrow cavity as Butlin was led to expect *from its narrowness*. The number of lamellae about the Haversian canals was not larger than in the normal, but the arrangement was different and most complex. The lacunae and canaliculi throughout did not strikingly differ from those in ordinary bone.

Von Recklinghausen noted that it was difficult to judge under the microscope whether the new tissue was forming or in a regressive state. Osteitis deformans and osteomalacia were once confused. The cysts had smooth fibrous walls and were surrounded by fatty marrow. The cartilage of the head of the bone was thin—that of the head fibrillated. In one case of osteitis deformans there were cysts and fibromas. The diaphysis was the usual seat of cysts.

The bone and fibrous tissue about the disease seemed finished and normal. Microscopically, there was very little uncalcified osteoid tissue

and the soft connective tissue seldom young looking and rich in cells, but rather poor in cells and fibrillar. The cyst wall often resembled very old sclerotic connective tissue so that one looked upon the process as stopped—finished years ago. For a long-since ended process spoke the great firmness, the thickness, the perfect compact character of those osseous plates, which formed the very thin tumor layers with perforations, these being formed as part of the disease.

So we have before us a form of repair (healing) while the disease existed decades earlier.

Again he describes giant-cell myeloid tumors rich in granular brown pigmented cells in the new cortical substance. The periosteum takes little part in the formation of the new fibrous tissue rich in bone rods. The bone marrow and the bone tissue do the reproducing, hence the term osteitis fibrosa osteoplastica.

Certain bones seem to be preferred; yet all are involved. Those parts of the bone are most affected which do the most work.

The sarcomas, too, develop preferably at points of greatest pressure and traction. In these parts the compacta is thickest. In cancers with osteitis fibrosa he attributes the new bone and fibrous tissue formation in advance of the cancer metastasis to reactive irritation with inflammation. The circulatory congestion is marked. He notes that bone formation in osteomalacia prefers to locate at attachments of muscle and ligaments. He says:—

"Osteitis deformans or local osteomalacia is an osteitis deserving the added title fibrosa."

"The bulging lamellar arrangement is due to absorption (rarifying osteitis) preceding later bone apposition."

Packard, Steele, and Kirkbride:

PATHOLOGY: Excessive pigmentation of the skin of abdomen. Brittle hair growth. Spleen large. Giant-cell sarcoma of frontal bone with metastasis. Diploe present only in frontal and occipital bones. At base of brain the vessels are overfull. Clavicle cuts more easily than normal. Unaffected bone alternates with spaces due to absorption. These spaces are filled with a fibrous tissue reticulum, the cells being mostly spindle shaped and many round cells with deeply staining nuclei, polynuclear leucocytes, a few nucleated red corpuscles, and some fat cells. Most of the spaces are exceedingly vascular. In many vessels there is only one layer, this is of endothelial cells. No larger arteries are seen. The reticular layer runs almost to the periosteum—a thin shell of com-

pacta alone remaining. In the interspaces are numerous groups of giant cells. These cells lie on the edges of the unaffected bone, absorbing it. Running through these interspaces and the bone itself are masses of closely packed cells resembling osteoblasts with a fibrous matrix. This is evidently an attempt at formation of new bone, but in no place is it calcified. The dividing line between the new and unabsorbed bone is sharp and the processes are evidently distinct.

Skull: The distinction between diploe and tables is lost. There is a thin irregular plate of compact bone under the periosteum, but elsewhere it is honeycombed by absorption spaces giving it a porous structure. The spaces contain the same material as seen in the clavicle though not so many giant cells. There are plenty of capillaries, but no large arteries.

Stilling: Bone cuts easily. Some can be indented with the finger nail. Periosteum rich in blood, not thick, nor adherent, deep grooves for vessels.

The two tables of skull bones cannot be distinguished from the diploe —porous with a very thin compacta within and without.

Contents of Spaces: Red marrow. Some large spaces contain a fibrous tissue or fatty marrow.

Senile osteoporotic appearance of vertebrae. Findings in all the bones are similar. The Haversian and intermediate lamellar systems are often imperfect and abrupt, but very numerous. Where a vessel pierces a bone plate a lamellar system is seen. In some trabeculae the lamellar system may show parallel running lacunae, but in others these lacunae run in all directions. The separate cancelli are very irregular in boundaries; not one has a perfectly flat border. All are riddled with Howship's lacunae, perforated by canals and pierced by resorption spaces. Numerous Haversian canals pierce the continuity of the thin cortex. There are large numbers of giant cells in grooves. Apposition of bone is alongside of resorption. Resorption grooves are often covered by new osteoid with good osteoblastic lining. Often this bone is fibrous. The bone cells are often sparse and not always regularly arranged and the lacunae may lack canaliculi or have only short ones. The marrow in the worst involvement is of a streaked, very vascular connective tissue, sometimes rich in cells. These cells are spindle-shaped connective tissue cells with large nuclei, some polygonal with granular protoplasm. He compares the disease with leontiasis ossea and elephantiasis of the soft parts in younger people.

Elting, in reporting a case of osteitis deformans, very properly says: "The difference in anatomical findings of writers is probably because the disease was studied at different stages. The venous dilatation seen in certain cases may be an etiological factor, though this seems improbable." He thinks the bone pains are due to the distention of the periosteum as in rickets.

Higbee and Ellis: *Femur*—Compact portion 1.5 cm. thick. Much of the canal contains spicules of bone. Thick spongy bone is between canal and compacta. Marrow dark red and soft. Outer layer of skull cuts easily and is very vascular. The internal table is solid—dura adherent. Parts of external table are porous and vary in thickness from 1 cm. to 1 mm. Beneath this is a soft spongy bone or granular osteoid tissue in which are scattered nodules of relatively white, fairly compact bone. Internal layer uniformly solid but unevenly thick (.5 to 1.5 cm.). It is rougher than normal next to the dura. The mid zone is porous and friable. Pressure at the soft parts causes blood to gush from the inner surface. Microscopically, there is bone resorption and new fibro osteoid tissue. The Haversian canals of the inner table are very large and irregular, and some coalesce. There is new connective tissue about most of the vessels in the canals reaching to the bone, so that an endothelial lining to bone is not seen. The connective tissue is usually loose but is again fibrous. There are many giant cells in the Haversian canals of the inner table. They are within or on the border of the new connective tissue; many are close to the bone in lacunae. One field contains 58 giant cells. The mid zone (spongy mass) is made of small irregular islands of osteoid tissue and intervening structures of one or two types—dense acellular connective tissue and adipose tissue with a little connective tissue here and there. In this adipose tissue are a few mononuclear leucocytes. The adipose and fibrous tissue exceed the osteoid. Fewer giant cells are here. The osteoid contains bone cells but they look immature. Lamellae are seen in some fragments, but no Haversian canals. In the femur's more spongy portion, the connective tissue contains some large spaces filled with blood. No normal marrow.

There does not seem to be any essential difference in my findings from those of Sir James Paget, Butlin, Von Recklinghausen, Stilling, Packard, Steele and Kirkbride, Higbee and Ellis, Czerny, and Volkmann. The changes found in single bone involvement are the same as when many bones are affected. We will add to Von Recklinghausen's and Stilling's assertion that static, thermal, and vascular conditions are responsible for

the localization of the bone involvement that the blood-vessels are the source of the disease *in toto*. Paget himself classifies it as a chronic inflammation, the osteoporosis predominating over the productive changes. I would bring it in closer parallel to the general pathological processes that accompany chronic passive congestion. Here we have not infrequently intermittently overfilled vessels with edema and leakage followed by compensation by heart and vessels when repair and even excess of tissue formation occurs. This is best illustrated in the general pathology of the liver, heart, spleen, kidney, and even the bones when a long standing heart hypertrophy with irregular compensation exists. I have been in the habit of studying the bones from autopsies since 1905 and find without fail some of the changes found in the cases of Paget's disease in all cases of chronic passive congestion. The edema with widening (and sometimes granular condition) of lamellae, pigmentation of bone and lacunae, and pigmentation and large cell hyperplasia in marrow with frequent fibrosis.

In cases of cancer in the body, I have noted what is ordinarily called osteomalacia evidenced by an eosin-stained line looking like osteoid bordering the bone next the Haversian canals even when no metastases were present. The bone cells and large polygonal cells in the marrow next the bone described by Von Recklinghausen, Stilling, Packard, Steele and Kirkbride, Ewing, and Higbee and Ellis, are seen in my cases of myelogenous leukemia (photo 12), my bone transplant experiments (photo 21), cancer in bone (photo 11), sarcoma in bone, and wherever there is excess of fluid bathing the trabeculae, whether due to blood-vessel or blood fluid changes. Von Recklinghausen and Stilling refer to these changes as due to vital fluid coming in contact with bone. That the washing of the bone by fluid may modify the appearance of the marrow has its exaggerated significance and proof when we read H. Gideon Wells' report of myeloid sarcoma washed out of the bone, so that the typical appearance is no longer found in the marrow but can be seen in the growths elsewhere—as in the pleura.

Ewing, too, refers to this in describing the peculiar endotheliomas of bone, in which doubtless the polygonal cells described by him and those seen in our photographs are of the same origin.

The vessels have been described as congested, the blood gushing out on pressure.

Deep grooves are found along the bones (Baetjer describes such lines in x-rays in the cases of Hurwitz). Blood leakage, pigmentation of bone

and marrow are mentioned as a rule. There is no need to dwell on the relation of hyperemia, active and passive, to bone formation and destruction. I have written of it before. (See references.)

Spencer, in his Erasmus Wilson lectures, goes fully into this relationship, saying in brief that the bone changes are due to venous or arterial hyperemia.

Indeed this vascular hyperemia is the one condition on which all seem united, the deep grooves on the outside of bone and the wide spaces within being noted by all observers.

Those who have not seen pathological material have remarked about the arteriosclerotic vessels and heart pathology noted clinically (see Prince, Putnam, Hurwitz, Fussell, Fitz, etc.), yet the more minute examination of the vessels of bone and soft parts has seldom been made. When we note the frequency of origin as an infectious process (Edes, Watson, Painter, Franke, Czerny) and its comparison with elephantiasis, one cannot help but consider vascular thrombosis with later compensatory circulation as part of the pathology.

That bone formation and absorption are intimately bound together with vascular hyperemia was long ago proven (Spencer, Von Recklinghausen, Stilling). More recently experimenters have been able to cause metaplastic formation of bone in unusual places such as in the kidney by producing vascular hyperemia (see Harvey, Pearce, Asami and Doek). How the vascular condition is inaugurated has been left open by most observers, but congenital and acquired syphilis have had a large number of believers (Lannelongue, Achard, Fournier, Etienne, Oury and Claude). Claude and Oury reported Paget's disease and tabes in both mother and daughter, a case of Paget's disease in man and wife and that antisyphilitic treatment benefited six cases (Milean). That other infections, such as malaria (see Painter) might possibly be responsible is not to be lightly considered. Sir William Osler reported a case of blocked circulation with multiple gangrene in malarial fever and mentions the close relationship between malaria and Raynaud's disease (quoting Barlow and Monro).

Streptococcus, typhoid, and influenza germs have been starting points of infections which ended in either local, symmetrical, or finally generalized osteitis deformans (see Edes, Franke, Watson).

That it is originally a trophic condition and depends on spinal cord or peripheral nerve pathology has votaries (see Prince, Putnam

and Fitz). Maybe the scleroderma noted by Lewin, pigmented skin and rough hair (Packard, Steele and Kirkbride), may indicate a trophic change, but if their cases had such a grade of nerve thickening as seen in my photographs one can easily understand the skin changes as secondary to vessel changes as the basis of the entire process.

It is interesting to note Abbe's good results in operating on cases of osteitis deformans. One would expect to find readily healed tissues, for there is no evidence of active infection—no acute inflammation—and there are many potential osteoblasts present in the shape of liberated bone cells.

That the cells so frequently seen liberated from bone and plastered in its now granular matrix or against cancelli are capable of activity, either as connective tissue or bone formers, is not surprising. We have the authority of Bast, Koelliker, Arnold, Lossen, Macewen, Virchow, Shakspeare, to prove that bone cells may under good circumstances act progressively, the same as they may on other occasions act in a destructive manner. Koelliker has seen them coalesce to form the osteoclasts, in which case they must still retain some of the firmer texture of their original environment. Koelliker also describes them acting as osteoblasts. Again he has seen them separate into their original form. I have seen this, too, in bone absorption between dura mater and skull in bone, the seat of sarcoma and carcinoma, and in osteoid resorption after bone formation.

Fig. 21 shows these cells in case of formation and absorption of osteoid in experimental bone growth in muscle.

Watson's case, like our second case, suggests a local origin, possibly infectious. The right leg became inflamed, then the ankle, next the corresponding part of left leg was involved and on subsiding left pigmented spots. There was bending of bones with pain—the head later enlarging and the case developed into typical Paget's disease.

This case suggests others where erysipelas or other infections were the original source of trouble. See also Edes' case, which began with facial erysipelas. It also brings to mind the comparison made by Von Recklinghausen, Stilling, Gruber, etc., to elephantiasis following infections.

As to the pituitary, thyroid, and adrenal in their relation to osteitis deformans, I think endocrines go ahead acting in osteitis deformans, only they are dealing with modified vessels and tissues and their action

is exaggerated or moderated accordingly. There was evidence in my second case where trauma and phlebitis were apparently the basis for a local osteitis, that the pituitary was modified (calcified structures about it), but must have returned to a normal function later on.

Goldthwait, Painter, Osgood, and McCrudden, in studying the chemistry of osteomalacia, say "The normal function of marginal cells or bone corpuscles is so altered by certain substances that absorption occurs by them." Castration caused marked excretion of calcium. Castration during the decalcification period reversed the process.

McCallum and Voegtlin—"In osteomalacia, rickets, etc., the tetany is possibly due, as Erdheim suggests, to lesions of parathyroid gland." They prove that excess of calcium reduces nerve irritability, and reduction of these salts causes tetany.

The influence of internal secretions on vessels and other tissues through sympathetic nerves is well indicated in work by Orr and Rows, who say "The sympathetic system may then be held responsible for localization of atrophic and sclerotic changes in the spinal cord, *i.e.*, those supplied by pial vessels."

Those who find bone lesions associated with tabes and syringomyelia (Dercum, Spiller, Marinesco, etc.), will find evidence that the vessels, after all, may be the main source of trouble—the ductless glands merely exaggerating their anatomical and physiological weakness.

CONCLUSIONS.

We have, then, osteoporosis with disappearance of bone by lacunar absorption and chemical (vital fluid?) dissolution, accompanied by new formation of bone. In my case the new formation is not so marked as in those reported by others. The active process seems to have been completed.

There is evidence of breaking down of bone—I would say bending of trabeculae crushing down on neighboring cancelli, obliterating some canals and assisting in the formation of others.

There is marked vascular degeneration with varicose vessels, thrombosis, congestion, leakage with edema and minute hemorrhages. The surrounding tissues are modified to a certain extent as evidenced by changes in vessels, nerves, muscles, and tendons. It is suggested that this is due to the bone absorption in their neighborhood throwing them in contact with unaccustomed (unusual) neighboring material. In the case of muscle attachments the distortion and microscopical changes are especially marked.

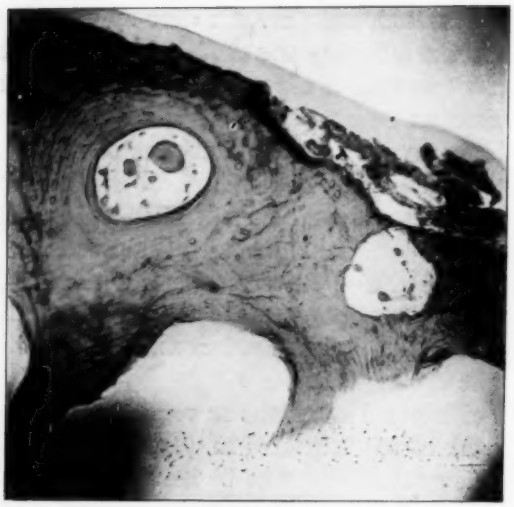

FIG. 1.—Tibia. At periosteum. Canal exposed. Myxomatous marrow.

FIG. 2.—Vertebra. Bone canals exposed at cartilage as bone cancellus is absorbed. Cartilage calcified.

FIG. 3.—Vertebra. Marrow exposed by disappearance of trabeculae of bone adjoining fibrous cartilage.

FIG. 4.—Rib. Vessel of periosteum full of marrow cells.

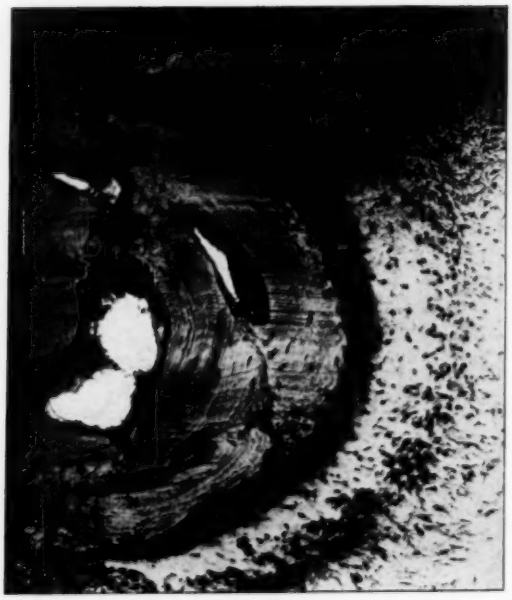

FIG. 5.—Rib. Narrow upper border. Bone metaplasia in muscle attachment. Large marrow spaces.

FIG. 6.—Rib. Broad lower border. Degenerate vessel in marrow.

FIG. 7.—Radius at attachment of biceps. Erratic bone architecture. Bone absorption and new formation on the surface. Bone spicules and metaplasia in tendon.

FIG. 8.—Clavicle. Granular bone. Erratic structure. Lacunar absorption.

FIG. 9.—Vertebra. Erosion of cancellus. Howship's lacunae. Cellular marrow. Many congested capillaries (pale). Little fat.

FIG. 10.—Vertebra. Polygonal bone cells of cancellus.

FIG. 11.—From a vertebra, the seat of carcinoma metastasis. Same appearance as in No. 10.

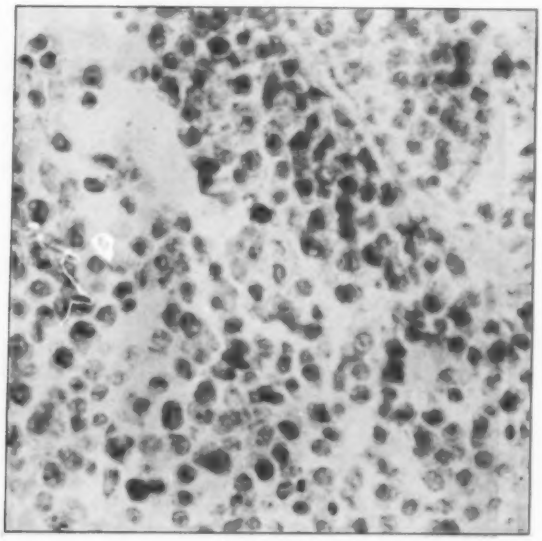

FIG. 12.—From case of myelogenous leukemia. Similar cells to Nos. 10 and 11.

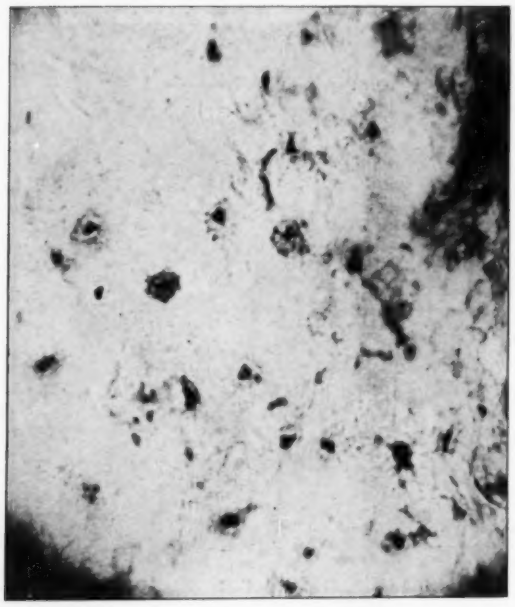

FIG. 13.—Radius. Resolving bone. Bone cells enlarged. Wide lacunae. Virchow's bone territories. Uneven calcification.

FIG. 14.—Tibia. Cyst wall. Forming cyst in adjacent fibrous tissue. Bone spicule undergoing disintegration.

FIG. 15.—Tibia. Same as No. 14, with adjacent fatty marrow.

FIG. 16.—Tibia. Nutrient artery. Calcified media.

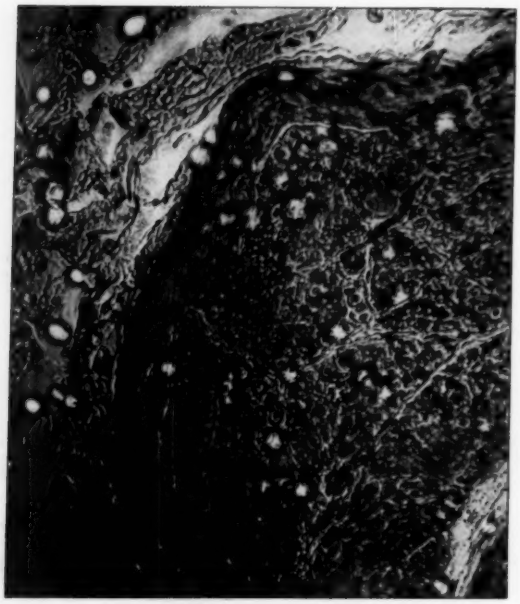

FIG. 17.—Rib. Nerve in periosteum. Nerve cells hyperplastic. Perineurium thickened.

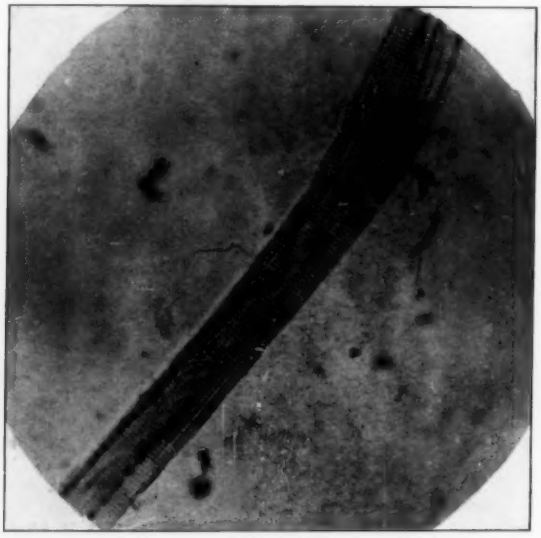

FIG. 18.—Rib. Muscle at rib. Nuclei increased and in rows.

FIG. 19.—Spleen. Pigment deposit in deeper layer of thick fibrous capsule.

FIG. 20.—Sagittal sections of clavicle, radius, vertebra, and tibia.

FIG. 21.—Polygonal bone cells. Transplant of bone into muscle. Experimental.

FIG. 22.—Polygonal bone cells. Edematous widened lamellae.

The bone itself shows reversion to a fibrous type in places; there is a metaplasia to myxomatous tissue and the marrow is myxomatous, fibrous or cellular, the bone cells taking part in the process. There is what appears as a reversion of marrow in some bones to the embryonal type—containing small and large round cells, megalokaryocytes and normoblasts—possibly compensatory. The bone cell multiplication is an essential part of the disease.

The pathological changes vary in the different bones and in various parts of the same bone. This will be noted too in the appended pathological reports of various cases by different workers.

There is evidence of analogous conditions to bone in the organs and tissues (see kidney, spleen, muscle), and nerves. This is best noted in the tendency to overgrowth-cell multiplication. The circulation has been erratic for years with intermittent compensation and the reverse, the bones, organs, and soft parts being correspondingly affected. The changes involved correspond to what one finds in chronic inflammation or in resolution of acute inflammation where repair is the most important factor.

My impression is that we have a primary blood-vessel pathology like one sees in syphilis, hereditary or acquired, with accompanying bone changes, such as one finds on a small scale in chronic passive congestion or infections of a chronic character. It is not at all improbable that malaria, typhoid, influenza, erysipelas, or parasitic germs could produce such vascular lesions, accompanied by local and general osteitis deformans.

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DISCUSSION.

DR. L. B. MORRISON, Boston: It has certainly been very instructive, listening to Dr. Cone's well-prepared paper. Unfortunately I know very little of the disease from the pathological standpoint, but literature up to the present time reveals that very little is known more than Paget discovered in 1876. In the past five years of my work I have seen something like 47

cases, which makes me feel that it is not a rare disease. There have been many classifications, but none seem to meet all conditions. I shall not attempt to discuss the paper, but by showing a few slides will bring out some of the points of interest. In going over my series I note this: that the changes in the bone seem to begin first at the cartilages and extend into the compact bone at the epiphyses. This is noted both at the knees and sacro-iliac synchondroses. It suggests an infectious origin. In comparing it with infectious lesions involving bones we get coarse trabeculation in the bone. In regard to calcification of the arteries, I believe this is an end-result rather than the cause in this disease.

Dr. T. Halsted Myers, New York City: Dr. Cone's paper is timely in that the etiology and microscopic pathology of Paget's disease, osteomalacia and osteopsathyrosis still present many unsolved problems. I wish to describe a case which combines symptoms of these three diseases.

Mr. N.; 43 years; W=95, H=4.11½. Chief complaint is progressive weakness of legs, and increasing deformities. Ten years ago first noted some weakness and instability as he walked. Gradual increase of symptoms, until the last six months he has had to use a cane, and after a block feels pain as well, in legs and hips. Never any swelling or inflammation in the joints.

Mr. N. seven years ago suffered for months with a severe attack of furunculosis and was in a week cured by taking brewers' yeast. He has had no other diseases. Eight years ago, following a slight trauma, he suffered his first fracture. It was of the right humerus and required three months to become solid.

While in St. Luke's Hospital, besides the examinations recorded below, he was examined as to his eyes, ears, nose, throat, and the cardiac, respiratory, gastro-intestinal, and genito-urinary systems, and nothing found which seemed suggestive as to etiology.

Examination of blood, December 14, 1921: Red cells, 4,900,000. Hg., 88 per cent. Leucocytes, 11,000. Poly., 77 per cent. L., 23 per cent. Reds, slight achromia. No poikilocytosis. No ova cytosis. No erythroblasts. White cells—No myeloblasts; no myelocytes. Blood cultures, December 17, 18, 19, 27—Negative. Chemistry—Urea nitrogen, 14.7 mg. per 100 c.c.; uric acid, 6.3; creatinin, 1.1; glucose, 77. Wassermann twice, negative. Urine (several times), 1020; acid, sugar, 0; albumen, 0, or slight trace. Never Bence-Jones proteid. No casts; few white blood cells.

X-rays showed a mixed process. There was great expansion of the diameters, some increase in length; decalcification involving both cortical and medullary parts, giving the bones a thin, spongy appearance, with a very thin cortex in most parts, though at points of stress thicker than normal. The decalcification also varied in degree in different parts, but never giving the appearance of cysts. There was also considerable increase in the density of the bone, very irregularly distributed, in small areas rather than in longitudinal striae, and in the medullary part especially. The bones involved were the skull, both humeri, both femora, and both tibiae, the entire pelvis and fifth lumbar vertebra. There were a number of small areas of decalcification, irregularly distributed in the flat cranial bones, and placque-like areas of increased bone deposit. The posterior clinoid processes seemed thicker than normal. The sella seemed normal in size.

On account of the pliability of the affected bones, the tibiae had bent forward and outward, the femoral shafts outward, and the necks downward to a right angle, while the sides of the pelvis in the region of the acetabula

had been pushed far inward and upward; the ilia had bent forward at the sacroiliac joint, and the promontory of the sacrum had fallen forward with collapse of the fifth lumbar vertebra. These deformities, together with marked increase in the size of all the affected bones, produced a very small as well as deformed pelvis. The gait was very similar to that of double congenital dislocation of the hips. The deformity of the right humerus at site of fracture is 90 degrees backward, and two inches below, the bone bends 90 degrees inward. The peripheral part of the bone here is irregular and enlarged, but not thickened. The line of demarcation between healthy and affected bone is quite distinct in the lower part of the tibiae.

Diagnosis: These cases are very rare, extremely so in this country. In England and Central Europe more are seen, and there have appeared a number of well-worked-out articles describing these conditions, but in none I have seen has there been described any curative treatment or any positive proofs of the etiology. There seems to be some relation between late rickets and osteomalacia. Osteopsathyrosis is a closely related condition, with localized decalcifications, repeated fractures, and imperfect reparative power. The appearances in my case are not those of any form of specific disease. The duration of the disease as well as the absence of any primary focus would exclude malignant disease. A number of his teeth have apical abscesses, but the x-ray appearances of the bones are not those of the ordinary forms of osteomyelitis. It seems probable that there is a metabolic process going on now, diminishing the amount of bone salts he deposits. Possibly this may be controlled by the ductless glands, especially those we know influence growth very directly. In this case the thickening of the clinoid processes points toward irritation, perhaps, of the pituitary.

Mr. N. has a sister, 38 years old, who is very small, and poorly developed mentally.

I wish to thank Dr. L. C. Wood, Dr. LeWald and Dr. Wiener for their help while investigating this case.

THE MECHANICS OF A NEW PLASTER SHELL IN THE TREATMENT OF POTT'S DISEASE IN CHILDREN, WITH LATERAL X-RAY CONTROL.*

BY R. PLATO SCHWARTZ, A.B., M.D.

(From the Orthopaedic Clinic, Children's Hospital, Boston, Mass.)
Present Orthopaedic Surgeon J. N. Adam Memorial Hospital, Perrysburg, N. Y.

THE efficiency of apparatus which is elaborate in construction and of good appearance is too frequently accepted without conclusive proof. This paper will first present those fundamental principles which should always direct the treatment of Pott's disease, and upon this basis it will describe the mechanics of the posterior shell as an instrument through which these principles may be applied. The defects in the apparatus used heretofore have been recognized and their cause has been eliminated. The description of a new plaster shell is justified because it has thus far materially increased the efficiency of our treatment of Pott's disease.

The anterior portion of the spine is normally a flexible weight-bearing unit.[1] When any vertebral body becomes diseased, it forms a weakened link between the normal spine below, and the upper segment, which always bends in the direction of the greatest force,[2] while rigidity from muscle spasm attempts to immobilize the diseased area.

The nature of the lesion and the parts affected require that both mechanical and physiological principles be included in any form of therapy in this affection. These may be briefly stated as follows:

1. All superincumbent weight must be removed from the anterior portion of the vertebral column.

2. Spinal motion must be reduced to a minimum.

3. Deformity should be prevented, and when present, its prominence should be reduced by compensatory curves, and modification of the posterior spinous processes,[3] without separating the surfaces of the diseased vertebrae.

*Read before the Boston Orthopaedic Club, September 16, 1921.

4. General hygiene, good food, and heliotherapy should constitute an important part of any rational treatment of this disease.

Normal ossification is a slow process, and disease of any part of the osseous system, in children under sixteen years of age, should therefore be regarded as an affection of developing bone.

In normal vertebrae new centers of ossification continue to develop up to, and including, the sixteenth year,[4] and their epiphyses do not usually unite until the average adult is twenty-five years of age.[5] The infant's spine has two primary curves, the dorsal and sacral.[6] It is important to note that the cervical and lumbar curves are acquired characteristics, forced upon the spinal column by the normal erect posture, which is essentially one of effort. The lumbar convexity, which is greater than any of those above it, is the last to be acquired. This leads to the conclusion that in a growing spine, which has become diseased, deformity may be prevented, or, if present, the spine may still be made relatively straight, by placing it in a position which favors the formation of compensatory curves and modifies the shape of the posterior spinous processes.

The cords of these arcs form a continuous line which is the perpendicular of this column; *i.e.*, a perpendicular drawn from the tip of the odontoid process impinges upon the second and the eleventh dorsal vertebrae and forms the cords of these vertebral curves. The line, thus formed, when traced onwards beyond the lumbar vertebrae, falls at right angles to a line drawn across the pelvis from one acetabulum to the other. Thus the weight of the body is transferred from the spine to a strong transverse arch formed by the thick iliopectineal line, and thence is transferred to another arch constructed by the femoral necks.

The function of any vertebral body between the cranium and the sacrum is to support and transmit weight and facilitate the movement of the parts above it when the body is erect.[7] If the structure of a vertebral body is altered by injury or disease its treatment should be the same in principle as that applied to a similar affection of bone in the extremities. "Rest was the routine practice of John Hunter, the most efficient instrument of John Hilton, and the creed and ritual of Hugh Owen Thomas."[8] Today the value of rest is so generally recognized that it has become an essential agent in the treatment of all acute affections, as well as in many of the more chronic diseases. Only when all superincumbent weight is removed and motion of the affected verte-

bral bodies is reduced to a minimum can we consider the tuberculous spine at rest.

Pott's disease in children frequently produces a most distressing figure when treatment is neglected, and occasionally this is true when treatment is more continuous than efficient. It always modifies and usually prevents the development of the affected vertebrae and subsequently distorts the shape of the normal spine above and below the lesion.[9] The treatment of this disease should promote healing with a minimum amount of deformity when the patient reaches adult life. Such a result can be most assured only when the growth of the normal spine is permitted while the lesion is being treated. The prognosis of a tuberculous spine at a given level is determined by, first, the time at which the disease is recognized; second, the amount of destruction present, and third, the degree to which subsequent treatment limits the normal function of the vertebral bodies.

In early cases we may prevent the formation of a kyphos, while for those in which it has already developed, we may accept the deformity and attempt only to prevent its further increase, or we may attempt to reduce the prominence of the existing deformity while the affected vertebrae are under treatment. If the latter is our purpose, as it properly should be, then there are two methods by which it may be accomplished. Separation of the diseased vertebral bodies by strong pressure will decrease its prominence; or the development of compensatory curves in the normal spine will disguise the relative prominence of the deformity without disturbing that portion of the affected vertebrae which is most favorable for bony union. Since our ultimate aim is to deliver the patient to adult life with a minimum amount of deformity it follows that our immediate need rests in those measures which are most conducive to bone formation in the affected area. Any method, therefore, which will induce the formation of compensatory curves and modify the shape of the posterior spinous processes without separation of the surfaces of the tuberculous vertebral bodies is indicated in the treatment of this affection.

Apparatus can effectively prevent all motion and remove the weight from an extremity, thus enforcing rest of the limb while the patient is erect. But at present there is no splint for the spine which will meet these requirements and thereby prevent deformity during the acute stage of this disease. A back brace may reduce all motion of the affected vertebrae, but it cannot be tolerated by the patient when it

is applied with sufficient force to remove all superincumbent weight from the vertebral bodies.[10]

Apparatus as it has been applied has failed to relieve the erect spine from superincumbent weight and we are forced to consider a change of position in order to remove this crushing effect from the diseased area. Since the time of Percival Pott, who enforced prolonged rest in the prone position, by the use of setons and issues,[11] recumbency has proven to be an essential therapeutic measure in the treatment of tuberculous vertebrae.

During recent years heliotherapy has proven to be of distinct value in the treatment of all tuberculous affections. The most satisfactory results require a graduated exposure of successive zones of the patient's body until the whole surface is well pigmented, then the dorsal and ventral surfaces are alternately exposed for stated intervals throughout the day. Such procedure obviously requires a turning of the patient and enforces the employment of a method which will eliminate spinal motion during this action. In fact the daily nursing care necessitates such changes of position that the same requirements must be met even though heliotherapy is not employed.

The treatment of tuberculosis of the spine in the Children's Hospital, Boston, has never favored forceful correction of the deformity with anaesthesia. Under the direction of Dr. R. W. Lovett, there has been one continuous effort to institute a form of treatment which would conform to those essential surgical principles presented by this affection. The Bradford frame with pads, then the plaster bed similar to that which was applied by Fink[12] were both used to advantage in continuous recumbent treatment. At that time the acquired deformity was accepted and neither form of apparatus then at hand was designed to minimize its prominence. To meet this necessity the posterior plaster shell was made to differ from the original plaster bed in that it was cut transversely at the level of the apex of the kyphos and joined together by hinges on each side, while a long turnbuckle connected the head of the shell to a heavy plaster pedestal beneath the buttock. By shortening the turnbuckle the convexity of the shell was increased and hyperextension of the spine was secured. (See Fig. 1.)

Although changes in detail were made from time to time, and definite improvements resulted in better construction, the effect of this apparatus was anticipated but not proven. The apex of the kyphos always determined the level of the fulcrum in the posterior shell and its

efficiency was granted when pressure upon the kyphos was indicated by hyperemia of the skin. The first requirement, therefore, was to obtain direct evidence as to the effect which this shell was producing upon the diseased area and the spine as a unit.

Any index by which the progress of recovery may be followed in a given case and known lesion is of definite value. It is certainly advantageous, if not essential, to the patient that lateral x-rays of the spine be made at stated intervals during the course of Pott's disease. By this means definite information can be obtained, first, as to the recession of the active process; second, as to the rapidity of bone formation, and third, as to the efficiency of the apparatus in preventing deformity or decreasing that which is present. Lateral views of the spine with the patient in position on the posterior shell before and after hyperextension were, therefore, indicated.

The errors revealed by the x-ray were not surprising when the mechanics of the machine acting upon the spine were taken into full account. The posterior shell, when hyperextended, consists of two resistant, or relatively constrained parts, which by a certain predetermined intermotion serve to modify force so as to produce a desired kind of work, and it may, therefore, be properly called a machine. Through this device gravity acts upon the patient's trunk and head through two levers of the first class, over a common fulcrum, and the force of this action, *i.e.*, the work done by this machine, is increased each time the turnbuckle is shortened to increase the hyperextension. According to the laws of physics which govern this type of machine it is known that the greatest amount of work is done by the longest lever, when the weight to be lifted and the force applied remain constant. The point at which the most of this force is expended upon the anterior portion of the vertebral column lies opposite the centre of motion, *i.e.*, the fulcrum of the shell. In keeping with these laws it was found by x-ray that in lesions above the seventh dorsal vertebrae, hyperextension of the shell caused the apex of the kyphos to be pulled down on the distal portion, while in lesions below the eighth dorsal the kyphos was displaced on the proximal segment. It was demonstrated, therefore, that when the contour of the shell was changed from the level bed which it had formed, to two inclined planes, the patient's body, being loose within it, would shift in the direction of the lever which did the most work. There is only one level of the body at which the length and weight of the parts above and below would do the same amount of work when placed over a fulcrum. Displacement of the kyphos resulted, therefore,

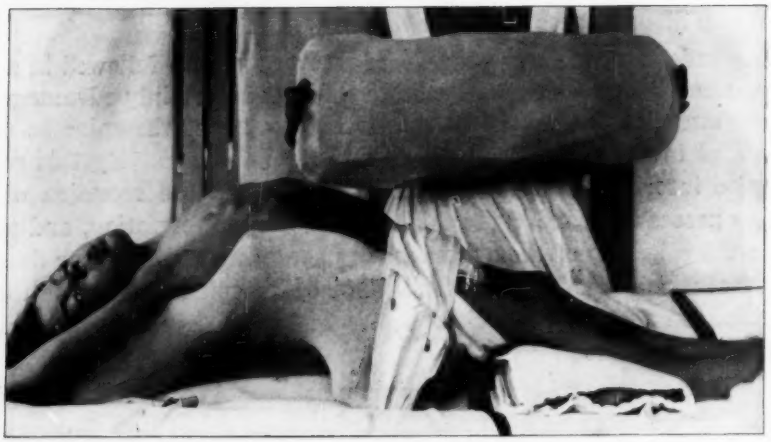

FIG. 1.—Patient on posterior shell, hyperextended by turnbuckle. (Note, hip flexion and hyperextended knees.)

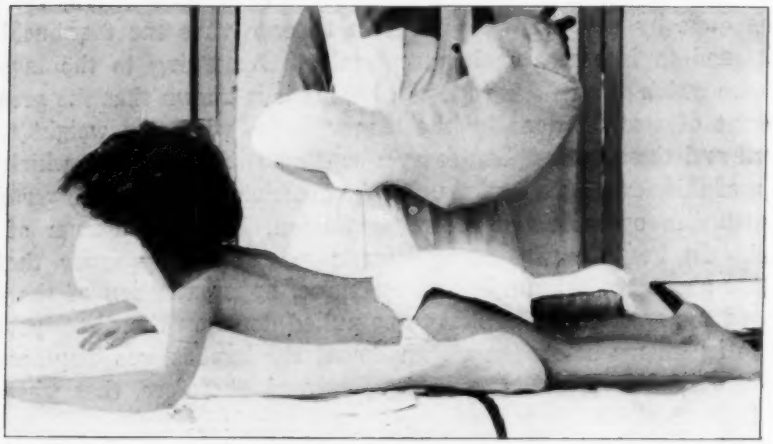

FIG. 2.—Patient on anterior shell. (Note, kyphos in dorsal region.)

FIG. 3—M. Y. Diseased vertebrae in apposition on admission. July 7, 1920.

FIG 4.—M. Y. Patient on old shell, without hyperextension, July 21, 1920. Fulcrum opposite apex of kyphos. (Note, diseased vertebrae are not separated.)

FIG. 5—M. Y. Shell hyperextended, July 21, 1920. Kyphos displaced onto proximal half. Compensatory curve created in lumbar region where least indicated. (Note, diseased vertebrae are not separated.)

FIG. 6.—R. Y. Diseased vertebrae, 2nd and 3rd lumbar, in apposition on admission, Jan. 9, 1920.

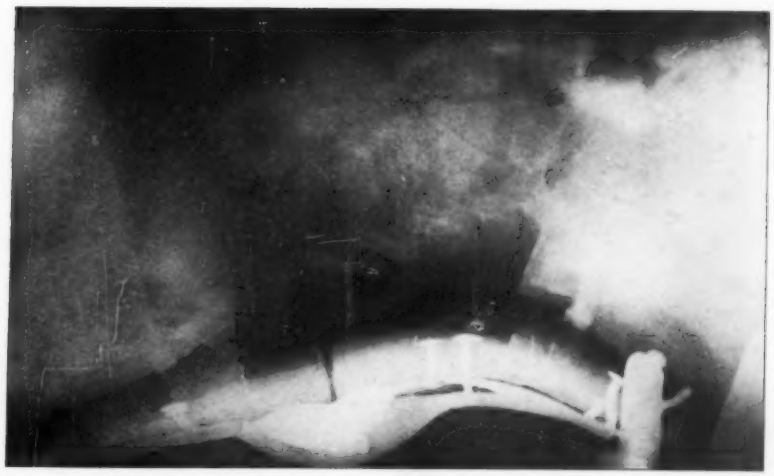

FIG. 7.—R. Y. On posterior shell with transverse cut placed at level of 1st lumbar. Note slight separation of 2nd and 3rd lumbar vertebrae which are distal to the fulcrum when the shell is not hyperextended. Jan. 13, 1920.

FIG. 8.—R. Y. On posterior shell, turnbuckle has been shortened, producing hyperextension. Note that the diseased area is now directly over the fulcrum and that the affected vertebrae are widely separated. Jan. 15, 1920.

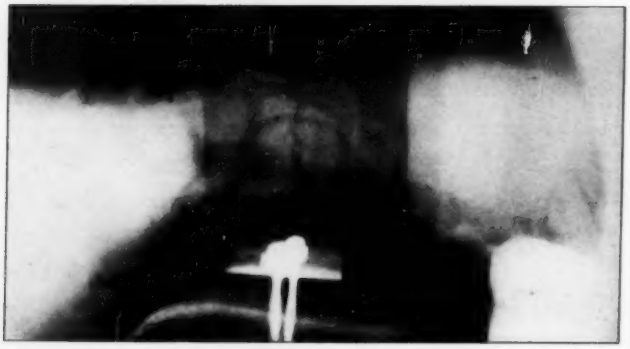

FIG. 9.—R. Y. On author's shell, Jan. 1, 1920. The 2nd and 3rd lumbar vertebrae, which rest in the center of the adjustable fulcrum, are again in apposition without recurrence of the deformity. Note the compensatory curves above and below the lesion.

FIG. 10.—The finished shell is being removed by cutting the plaster in the midline anteriorly and spreading the sides well apart.

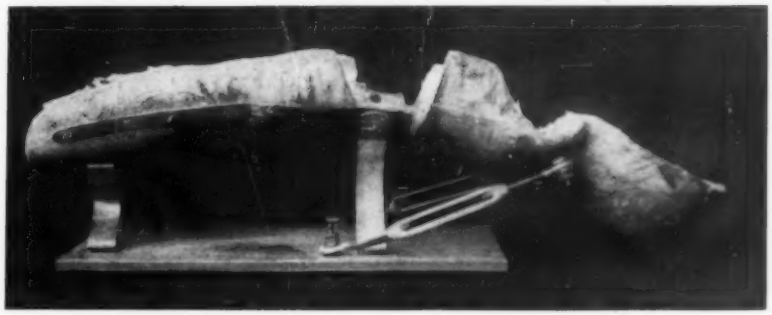

FIG. 11.—The old shell with the transverse cut, hinges, and turnbuckles. The notches in the sides provide for lateral x-rays of the diseased area of the spine.

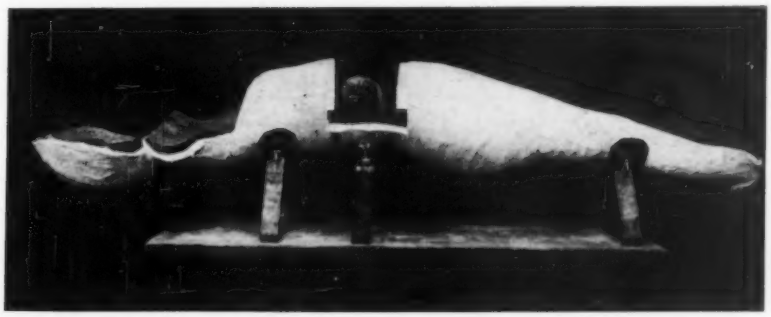

FIG. 12.—The author's shell with adjustable fulcrum. Felt lining is in place and the stockinet cover is to be applied before patient is placed in shell.

except at this level, when the fulcrum was placed opposite the apex and the shell was hyperextended by means of the turnbuckle. When thus displaced, a compensatory curve was created in only one segment of the spine, and in the absence of any form of control there was grave danger of this curve being much greater than necessary or perhaps formed where it was least indicated. However, an advantage rested in the fact that when thus displaced, the corrective force applied was seldom of sufficient intensity to separate the diseased vertebral bodies, (Figs. 3, 4 and 5.) It is obvious from that which has already been demonstrated that hyperextension should be increased only when great care is employed, and frequent observations reveal that the force exerted is not sufficient to separate the diseased vertebral bodies, and in no case should it ever pass beyond that point where the deformity is definitely compensated by other curves (Figs. 6, 7, 8 and 9).

The level at which the fulcrum should be placed in order to work upon both segments of the spine has been determined by lateral views of the kyphos in a series of cases with lesions ranging from the third dorsal to the last lumbar vertebra. The estimates were made with reference to the amount of displacement which resulted from hyperextension when the fulcrum was placed opposite the apex of the kyphos, and the following figures are approximately correct.

The transverse cut should be located at these levels with respect to the apex of the kyphos.)

3rd	dorsal vertebra	1½ inches below
4th	" "	1 inch below
5th	" "	¾ " "
6th	" "	½ " "
7th	" "	Opposite apex
8th	" "	½ inch above
9th	" "	¾ " "
10th	" "	1 " "
11th & 12th	" "	1¼ " "
1st & 2nd lumbar	" "	1½ " "
3rd & 4th	" "	1¾ to 2 inches above

The mechanical advantage of the posterior shell is essentially dependent upon its length as well as the position of the fulcrum. If the thighs are not supported, very definite objections result; first, the legs act as a lever of the first class over the end of the shell, as a fulcrum, and the lower portion of the spine is subjected to a range of motion which is not compatible with efficient treatment of this disease; second, flexion deformity at the hips is likely to develop; and third, hyper-

extension of the knees with relaxation of the ligamentous capsule may result from continuous strain thereon. (See Fig. 1).

Since these defects were demonstrated, this apparatus has been constructed in the following manner. It consists of a posterior shell and an anterior lid (see Fig. 2), both of which are made of plaster, the ordinary five-inch bandages being used. The posterior shell is made by putting a stockinet shirt upon the patient, from head to knees inclusive. A hammock is swung from a frame[13] (see Fig. 10) and the patient is placed face down with the arms at right angles to the body, and the apex of the kyphos is marked with an indelible pencil. The head, spine, and legs are held in the same straight line and the first plaster bandage is applied in continuous turns from the knees to the axillae. The plaster is then continued over the shoulders, neck, and head by half turns, which should extend well out over each shoulder and include each side of the head. Successive half-turns should then be applied to the back and thighs, extending to the mid-axillary line on each side, and the last plaster should make continuous turns as did the first. The posterior shell should not be more than one-half inch in thickness, and the neck should receive special attention, since it is most likely to be the weakest point. The shell is removed by making a longitudinal cut on the ventral surface and spreading the sides well apart (see Fig. 10). Immediately after removal the edges of the shell should be trimmed and a circular opening of ample size cut out for the use of the bed-pan. The transverse cut, which forms the fulcrum, should not divide the shell completely until two long hinges made of soft strap iron have been applied to the back of the shell. Two uprights about four inches in height are bolted to the lower half of the shell, which is then mounted to a long wooden base. With the distal segment of the shell thus firmly anchored, the proximal segment may be raised or lowered on the hinges which connect it to the lower half. In order to control the angle at which these segments shall rest, two turnbuckles are unscrewed to their greatest length and then bolted to each side of the neck of the shell. With the head of the shell at its highest point, the free end of each turnbuckle is fastened to the base. This done, the head may be lowered and held at any desired angle by shortening the turnbuckles. (See Fig. 11.) The shell is lined with gray felt and an extra thickness is placed along each side of the spine in the region of the kyphos. These are all held in place by wire thread and attached to only one segment of the shell, which is then entirely covered by stockinet, and oiled silk is sewed around the hole made to facilitate nursing care.

After completing the posterior shell and determining its efficiency by lateral x-ray negatives, the anterior lid should be made. With the patient in the posterior shell, a sheet of cotton is placed anteriorly and the lid is made to extend from the mouth to the knees by applying successive layers of plaster bandage in this direction. When dry, the lid is padded with a few layers of cotton and covered with stockinet (see Fig. 2).

The purpose of this anterior lid is to prevent motion of the spine while the patient is being turned. It is applied and strapped firmly to the patient on the posterior shell and after he is turned, the straps are loosened and the posterior shell is removed, leaving the patient to rest on the rigid anterior shell. (See Fig. 2.)

The time and skill required for construction of this shell, together with the x-ray evidence already set forth, suggested the need of a new apparatus, identical in principle, but essentially different in design, so that it would be more efficient and its application would not be limited to those localities where skilled mechanics are available.

A new shell which has been in use at the Children's Hospital, Boston, since June, 1921, was, therefore, designed by the author. (See Fig. 12.) It is decidedly less expensive, much more simple in construction, and up to the present time has proven to be mechanically efficient, although its true value is still to be determined. Careful x-ray studies of the limited number of cases now available have revealed four important facts which are in keeping with the mechanical and physiological principles essential to the rational treatment of this disease.

1. There has been no tendency toward separation of the diseased vertebrae.
2. Deformity, when present, has been materially diminished by the formation of compensatory curves in the normal spine.
3. The adjustable fulcrum should always be as wide as the diseased area and it is most efficient when placed opposite the apex of the kyphos.
4. Thus constructed and placed, the fulcrum causes the force of gravity to be spent first upon the normal spine above and below the lesion, while the initial deformity remains unchanged.

These advantages have been constant in each of the twenty-six cases now being treated with this apparatus. This shell is not cut transversely and the hinges are replaced by a fulcrum which is adjustable in both the vertical and horizontal planes. This fulcrum consists of a padded strip of aluminium which fits within the shell at the level of the kyphos. The fulcrum may be raised or lowered on two long bolts

to which it is fastened (see Fig. 12). These bolts pass through both the shell and an iron support which is mounted to the base under the shell at the level of the kyphos. A nut is screwed on each bolt after it passes through the shell and a second one is applied after the bolts pass through the rigid iron support. By means of these nuts the fulcrum may be raised or lowered in the vertical plane at the level of the kyphos. Openings in the sides of the shell at each end of the fulcrum provide for the making of the x-rays, and the anterior lid is applied and used as with the previous apparatus. The fulcrum as it is now applied splints the diseased area, and the corrective force is always centered upon the normal vertebrae adjacent to the lesion.

CONCLUSIONS.

1. The defects of the old shell have been revealed and it has been made a practical instrument through which the fundamental principles of therapy may be applied in the treatment of Pott's disease.

2. X-ray controls are necessary to prove its efficiency.

3. The fulcrum should not be placed opposite the apex of the kyphos except in the region of the seventh dorsal vertebra.

4. In lesions above the seventh dorsal vertebra the fulcrum should be made below the apex of the kyphos, one-quarter of an inch for each vertebra above this level.

5. In lesions below the eighth dorsal the fulcrum should be made above the apex of the kyphos, approximately one-quarter of an inch for each vertebra below this level.

6. The new shell with an adjustable fulcrum has thus far, on a limited number of cases, overcome the defects of the old one. It is much more comfortable for the patient, easier to handle, and much less expensive; besides being fully practical for treatment in the home and out-patient department.

This paper was made possible by the suggestions and criticisms of Dr. R. W. Lovett and Dr. J. J. Morton, to whom I am most grateful. I wish to thank Mr. J. V. Footman, Children's Hospital, Boston, for his work on the illustrations.

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THE DAVIS METHOD OF REDUCTION OF CONGENITAL DISLOCATION OF THE HIP-JOINT.*

BY WILLIAM JACKSON MERRILL, A.B., M.D., PHILADELPHIA, PA.

It seemed fitting to bring before the Association at this time a fuller account of the Davis method of reduction of congenital luxation of the hip-joint. Inasmuch as the method is used by a number of orthopaedic surgeons of Philadelphia and elsewhere, and as many are not familiar with the steps of the procedure, it is important that it be recorded as it was used by Dr. Davis in the latter years of his life. He evolved the method prior to 1903, for during that year he published monographs concerning his treatment of congenital hips. At the time of its conception it was a distinct departure from the violence and brutality which characterized a circumduction method, purloined and exploited at the beginning of this century.

It is here most congruous to pay, in some measure, tribute to the man who contributed, not only many eminently valuable measures to the art of orthopaedic surgery, but also many proofs of the wisdom and benefits of conservatism. He often said, "Surgery, by the very nature of the art, is *destructive;* orthopaedic surgery is *constructive.*" Every phase of his life was characterized by gentleness. It was that destructive factor, violence, that turned him to the development of a method by which the reduction of a dislocated hip could be accomplished "by the minimum amount of force, with the maximum degree of safety." He especially emphasized the employment of gentleness advocated by Paci, and denounced most emphatically the manoeuver of Lorenz, which was precisely Paci's method with the addition of destructive violence.

Davis had an exceptional knowledge of anatomy, pathology, physiology, and mechanics so nicely balanced that he was always master of the situation, no matter how serious. He reviewed the various results of open operation and the serious consequences following the injuries inflicted by violent bloodless methods. He made a thorough study of the anatomo-pathologic conditions, evolved his method, which elim-

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inated some of the dangers and especially the violence of the circumduction method, urged gentleness, and emphasized the truth that the result is commensurate with the manner of treatment.

The Davis method employs*: direct pressure, flexion, internal rotation, abduction, and external rotation. It is as follows—*First phase*: The child is placed in the prone position upon a flat, firm table, having a square edge, and a firm, even padding sufficient to protect the ventral soft parts. The child must be so placed that the leg to be manipulated will hang downward close to the side of the table. An assistant fixes the pelvis by making pressure on it downward and toward the operator. An assistant grasps the foot and knee, flexes the knee, then flexes the thigh toward the axilla, internally rotating the thigh, making pressure toward the head of the femur in line of its axis, keeping the thigh close to the trunk. These movements are directed by the operator while he makes pressure on the trochanter downward and toward the tuber ischii. It is important to keep the thigh close to the body in the antero-posterior plane to prevent the head from moving inward and making direct pressure upon the sciatic nerve. The internal rotation relaxes the Y ligament and the external rotators. *Second phase:* When the head is at the posterior brim the operator grasps the knee and trochanter, extends the thigh toward the transverse plane of the pelvis, abducts the thigh, and within the bounds of safety makes pressure on the trochanter toward the acetabulum, at the same time gently rotates the thigh in and out. If by this means the head will not pass across the brim into the acetabulum the leg is placed in the position of the first phase and the head is pushed downward to the obturator groove. The resistant cases often require long-continued pressure, which must be firm but gentle, to carry the head across the brim or through the obturator groove. *Third phase:* when the head is at the thyroid foramen, external rotation and extension are made to carry the head upward through the cotyloid notch. *Fourth phase:* A plaster cast is so applied as to include the entire extremity, the thigh of the opposite leg, and extends to the lower thorax of the opposite side, when the luxation is unilateral. The same form of dressing is used for bilateral cases except for the lateral upward extension. The condition of the structures of the joint must determine the position of the extremity in the dressing. In the average case it is

*To avoid misunderstanding, an explanation of the movements designated in this article is here given: By flexion and extension is meant upward and downward movement in relation to the axis of the body. By ad- and abduction is meant movement anteriorly and posteriorly in relation to the sagittal plane.

as follows: The thigh is flexed, internally rotated, and abducted accordingly as is necessary to give the best position and stability.

Davis used, when necessary, extreme flexion, abduction, and internal rotation, and maintained this position (when he operated by two stages) until the resistant structures had yielded, before forcing the head to its desired position.

In the post-operative treatment Davis maintained flexion, abduction, and rotation until the x-ray and other clinical evidence indicated that the head, neck, and acetabulum would sustain the stress of weight-bearing without yielding, using casts or splints to sustain the position. The first cast was removed at the end of three to four weeks and the position of the head and neck was determined by palpation and x-ray. Casts or splints, reapplied at frequent intervals, secured the desired position and were substituted by an abduction brace until the roof of the acetabulum was capable of retaining the head.

When the bones were in a condition to withstand the stress of weight-bearing the patient began ambulation with the leg in the abducted position. Passive movements, massage, and exercises were given to hasten and insure the establishment of function. Long before his death he stated that there could be no fixed time for the bringing of the leg to the mid-line and the establishment of function: that each case must be handled according to the conditions found.

His method exercises a pressure rather than a leverage stress. By virtue of the mechanical principles involved, much greater force than is required by leverage stress to rupture sutures may be used with safety and the head pushed over or around the brim into the acetabulum. The leverage and torsion used in the flexion and rotation of the femur should be far below the limits of safety if the pressure stress be properly applied by the operator. When the head could not be pushed over the posterior brim of the acetabulum Davis manipulated it downward along the brim, forward through the obturator groove to the thyroid foramen and upward through the cotyloid notch into the acetabulum. In the older resistant cases when too great force has been required, he has operated in two stages. In the first, the head was pushed to the anterior plane, usually through the obturator groove and left at the thyroid foramen, the thigh internally rotated and abducted sufficiently, and flexed beyond 110 degrees and fixed in that position by splints or plaster. In the second stage, the head was pushed upward into the acetabulum and the thigh brought down to the desired position in flexion and abduction.

FIG. 1.

FIG. 2.

FIG. 3.

FIG. 4.

FIG. 5.

FIG. 6.

FIG. 7.

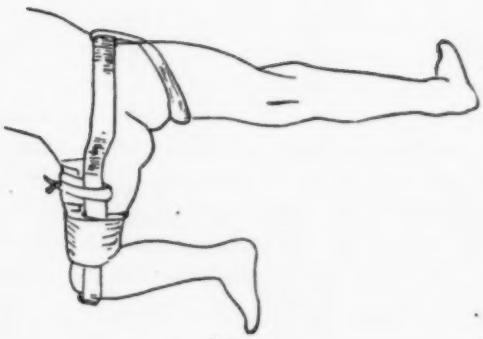

FIG. 8.

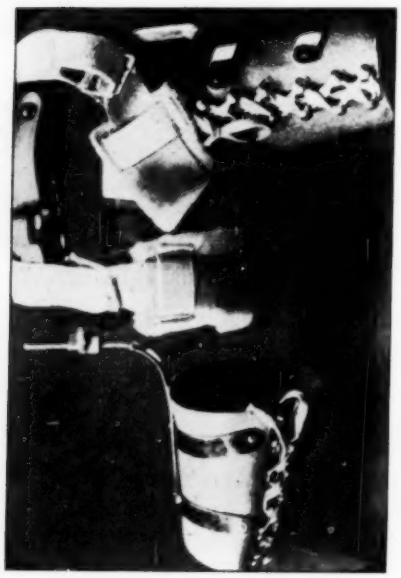

FIG. 9.

Davis modified his method in certain details from that which he used prior to 1910. The sand-bag was abandoned because it increased the difficulty in the control of the pelvis. Formerly when manipulating a hip-joint in order to promote the passage of the head to the anterior plane, he so placed the patient that the knee of the joint under treatment and the anterior superior spine of the opposite side rested on the table, and with the thigh in the horizontal plane of the pelvis, made pressure on the trochanter. This he discontinued because of the increased danger to the structures, especially to the femur. He laid great stress on the vital importance of keeping the thigh close to the body, also upon the necessity of internal rotation, this movement to be sufficient to bring the axis of the head and neck in line of the pressure exerted by the operator, to prevent a cross strain on the neck of the femur.

The efficiency and expediency of any therapeutic measure cannot be gauged by simple or even the average of conditions. It must be put to the severest test, under most adverse circumstances repeatedly, or else the conclusions are unwarranted. The easy cases of congenital luxation of the hip which are found only in the very young can be safely reduced by any method, if the proper care be exercised. This is not true of the more difficult conditions. At the present time long-neglected congenital luxation is rarely encountered, but a few cases are found, some of which

have a certain precocity of development and present conditions fraught with difficulties and danger, which increase inversely beyond the age of two years. The alteration in the structures caused by abnormal weight-bearing conditions and maldevelopment means that gentleness in its exact application must be abandoned and drastic measures employed. It is often desirable as well as necessary to use force, and comparatively great force can be applied if it be employed in the proper manner.

When the structures are distorted and resistant, prolonged force within the limits of safety must be used to bring the head of the femur from the posterior to the anterior plane. Davis tested his method by a very wide variation of conditions in children from one to twelve years of age.

Complete records of the results of treatment by the Davis method cannot be compiled, but his associates can bear witness that injuries to the structures were rare; moreover, that a high percentage of functional and anatomic cures were obtained.

It is unfortunate that the exact nature of some of his difficult cases cannot be recorded together with the splendid results he achieved in them, for such history would disclose his skill and gentleness much more fittingly than can the writer. He so handled every type of case that haematomas, extravasation, ecchymosis, paralysis, fractures, etc., were eliminated. Moreover, even a slight abrasion of the skin was rare.

DISCUSSION ON PAPER BY DR. MERRILL AND ALSO ON PAPER BY DR. Z. B. ADAMS
(Published in JOURNAL OF BONE AND JOINT SURGERY, July, 1922, page 523).

DR. RUSSELL A. HIBBS, New York City: Dr. Adams' paper has so many interesting suggestions that I wish he might tell us more of the details of Dr. Denucé's method.

In the first place it seems to me there must be more congenital dislocations of the hip at Bordeaux than we have in this country. At the Orthopedic Hospital in New York we have not reduced more than 350 in fifteen years. I know of no clinic in this country where such a number of congenital dislocations appear. I wish we might know more of the end-results, for, after all, that is the basis on which we have to estimate the results of treatment. As far as our work at the Orthopedic Hospital is concerned, I have felt for years that we must classify congenital dislocations of the hip more carefully. For instance, we consider one class, those with comparatively normal congenital dislocation—that is, with normal acetabulum, head, and shaft. I say comparatively normal, because none of them are perfectly normal. In this class we shall get better results than in any other. The other class, that is more difficult, is the one with torsion. Dr. Adams did not give me the impression that Dr. Denucé thought torsion was important. When torsion is more than 45 degrees I do not see how it is possible to get an anatomic correction.

As to the method of correction, our method is to correct the torsion primarily. Recently some of my associates have been correcting it after the dislocation has been reduced. That is for each individual man to decide. I am quite sure that our results at the Orthopedic Hospital are not quite as good as I should have said they were ten years ago. We are now making a study of all cases we are able to trace, covering the whole period of time that congenital dislocation has been treated by modern methods. When that report is complete it will be, I hope, very instructive to us and suggestive to others as to what the final results are.

As to the Commission Report, there is one point that impressed me as to what happens with the use of the machine that we use at the Orthopedic Hospital. The head is not pushed forward by the machine; it is pushed forward by the surgeon's hand. I think the Commission misunderstood the technic. In looking over these cases so far I feel that we have got a good many heads of the femur damaged but I think there were comparatively few of them damaged by the machine. I think the reason the machine prevents damaging the head is because it prevents it from making pressure against the ilium. The pressure is made against the trochanter by the trochanteric pad, and not against the head of the bone. Personally I feel that a machine which makes possible the operator exerting the whole pressure with his hand is safer than where a man has to exert the pressure with the machine.

Dr. E. W. Ryerson, Chicago: It would be very interesting to find out what the Committee thinks in regard to the after-treatment of these cases. You note the very wide discrepancy that exists between the method described by Dr. Adams as practised by Dr. Denucé and the methods with which most of us are familiar. In the Children's Hospital in Chicago we endeavor to get the child up and walking about, using the leg as soon as possible, with the idea of the possible stimulus to the growth of bone which normal use will make. Professor Denucé, if I heard Dr. Adams aright, advises no functional use whatever, no weight-bearing until eleven to thirteen months after reduction. It is barely possible that this difference in the treatment may have something to do with the development of the head of the bone. The results are very striking. I have now collected fifteen or more cases which were done many years ago, and, as Dr. Adams mentioned last year, we see a vast amount of difference between the head of the bone on the dislocated side and on the other side. Many of the cases have a great deal of traumatism during manipulative reposition and some do not. It would be interesting to have the Committee ascertain in an accurate scientific way whether the amount of damage done at operation has anything to do with the lack of development in the head in after years.

Dr. Walter Truslow, Brooklyn, N. Y.: I should like to ask Dr. Adams how much importance he places on one or two points he made,—the stroking of the adductor muscles, the use of strips of plaster as compared with our usual method of winding on prepared bandages, and the further muscle development of the femur.

Dr. J. T. Rugh, Philadelphia: Dr. Adams did not mention another point that has been strongly insisted upon,—that is, the further stretching of the flexor muscles of the thigh to bring the leg into complete extension. That has always been advocated to be done within the first two months. Now evidently

Dr. Denucé ties up this leg in a flexed position for six or eight months. When is stretching of the flexor muscles accomplished?

Dr. J. P. Lord, Omaha, Nebr.: I can very well see how this milder method of gently stroking the adductors will work in small children, three, four, five, or possibly six years of age, but in cases older than that I cannot conceive how it would accomplish very much. It is my experience that in some of the more difficult cases a very great amount of force is required, sometimes greater than I can give manually.

Dr. Reginald Sayre, New York: Dr. Adams says that after the leg has been manipulated it lies quietly on the table in extreme abduction, that is, it is brought down and manipulated and the head slips into the acetabulum. I can understand how it would, but I cannot understand how, with the gentle methods described, he is able to put the leg in extreme abduction lying flat on the table, because that means that you relax your tissues. As Dr. Lord says, in seven, eight, nine, and ten year old children, caressing it in that way seems to me extremely unlikely to get the leg into the extremely abducted position and having it lie there without resistance.

Dr. A. H. Freiberg, Cincinnati: I confess, perhaps somewhat rashly, that I am disappointed as a result of hearing Dr. Adams' paper. I had hoped for a demonstration showing that Dr. Denucé was doing something that we could not do and that the hips that were produced as a result of Dr. Denucé's method were entirely different from those we were accustomed to see. I hesitate somewhat to express the opinion that is really in my mind because congenital dislocation of the hip is not so frequent with us as in many other clinics. Quite the contrary, we see it rather rarely, so I have not had a very large experience; although in the years I have worked I have had more than a few and I must confess that I am rather satisfied as a result of the pictures I saw here, for they seem to have some bad femoral heads in France just as we have in this country. Nor do I see any greater amount of perfection in the observation of the final results than we have in general in this country.

I think we all recognize that a good many years ago we were all using too much force; not only more force than we are using now, but more force than was necessary. We were badly instructed. We began this method with force. Nobody knew how much force was required, and I look back with amazement to the manner in which we felt obliged to manipulate the hips of these little children. It took a while before we learned that this was not necessary. It seems to me that the manner of slipping the head into the acetabulum is largely dependent on the peculiarities of that hip. I feel that sometimes I can tell by the x-ray what manoeuver is going to be best in getting the head over the posterior rim of the acetabulum, but that is the way I nearly always get it in if I get it in at all. I am somewhat skeptical about methods of reduction. I remember some years ago Bade of Hanover came out with a good-sized book on this subject and I tried his method. In the first case it seemed to go well—the same way that Bade said it would—but no other one ever did afterward, so I do not think very much of that method of reducing a luxated hip.

I feel that I have had an insufficient demonstration of this method for judgment. Perhaps if I saw the method applied I should feel more favorably inclined toward it, but from the pictures we have seen there is nothing in the

Denucé method which is radically different from the methods we are using, and especially if we are using them with our brains and not only with our hands.

Dr. R. B. Osgood, Boston: I rise to the defense of Dr. Adams, and simply wish to testify to the experience we had in Boston. The testimony is not a personal one of reducing many hips, but in seeing many men in different parts of the country reduce many hips and then seeing the results in our own hospital in a large number of cases since Dr. Adams has been converted to Dr. Denucé's method. We have given him a chance to apply this method in this considerable number of cases in the Massachusetts General Hospital. Standing by him and seeing him reduce a hip is a very different thing from seeing a reduction by methods familiar to me in the hands of other men. There is no question in my mind and there is no question in the minds of the other men that the employment of force is very undesirable. The ease and quickness of reduction by these methods has been surprisingly pleasing. I wish Dr. Adams could demonstrate this method to you because I think you would be impressed in the same way that I have been. It is accurate, gentle, and apparently effective.

Dr. P. W. Roberts, New York: One point that Dr. Adams did not dwell upon that it seems to me he might tell us something about is the question of the capsule. We have to open a hip every once in a while where reduction is possible but where it does not stay reduced. Frequently we find that the capsule is contracted over the head and that is why the hip does not stay reduced. I would like to know Dr. Denucé's method in such cases.

Dr. W. C. Campbell, Memphis: I should like to ask regarding spontaneous dislocation of the hip. In the study he has made of congenital dislocation of the hip, I wonder if he has had any reports of cases in which the head was in the socket from birth and later came out. I had such a case in a girl of eleven. A case was reported by Dr. Ridlon several years ago in which the acetabulum was very much like a saucer. The child walked very well for one or two years and then began to limp. When I first saw the child I felt it was a congenital dislocation and was able to reduce it very easily though she was eleven years old. I felt I had done a very good piece of work until later the hip on the opposite side came out. This had to be reduced at a later time. I should like to know if this type has been considered.

Dr. J. J. Nutt, New York City: I am very much interested in this aftertreatment. I should like to ask Dr. Adams if, after all, the methods practised at Bordeaux do not bring about the same result as intra-articular pressure. I think it might be exactly the same as obtained with weight-bearing under regulation.

Dr. P. W. Nathan, New York City: It is rather surprising to me to find that we should still consider it necessary to discuss methods of reducing congenital dislocation of the hip. I have not in recent years found reduction in young children at all difficult. My difficulties lay not in the reduction but in the maintenance of the hip in place after reduction. This difficulty is caused by the anatomic conditions, namely, the partial or complete absence of the

acetabulum. It is evident that anatomical results cannot be attained if the head of the femur cannot be firmly anchored, no matter what the method of reduction.

It is my impression that in many cases, in which the ultimate functional result is poor, that this has been brought about by too forcible, or too often repeated attempts at reduction, over-zealous attempts to maintain the head of the bone in a faulty acetabulum, and rough manipulation as after-treatment. My own not inconsiderable experience leads me to believe that it is better to maintain the hip as near as possible to the rudimentary acetabulum for a considerable period, thus in many cases producing a false acetabulum and a good functional result, rather than lose this prospect by repeated reductions, etc. This is borne out by cases of uni- and bilateral congenital dislocation in adults, which were never reduced at all. A number of such patients walked without a limp and the anomaly was only discovered when these individuals were radiographed for other conditions. In these a well-developed pseudo-acetabulum was developed immediately above the rudimentary one.

I think our efforts at improving end-results in congenital dislocations should lie, not so much in the methods of reduction,—these are not so inadequate since the very forceful methods advocated by Lorenz have been abandoned,—but in devising means of maintaining the reduced head in the more or less rudimentary acetabulum. The method of Denucé, so well described by Dr. Adams, is no doubt valuable, but it does not appear to me that it is practical to carry it out when there are a large number of children to deal with in a city hospital. These children cannot be cared for at home in the manner described, and their maintenance in the hospitals, when all the requirements are fulfilled, is altogether too expensive at the present time, to make it feasible.

Dr. W. S. Baer, Baltimore: I think we all feel that in the past we have certainly used too much traumatism in the reduction of most of our cases of congenital dislocation of the hip. I think we all feel that damages have occurred about the hip, often due to traumatism. I certainly cannot reduce all cases, even up to seven years of age, with my hand; I often fail. Having failed, I put the case up in traction and allow the muscles to stretch for a period of two or three weeks. It seems to me, from what we have learned, that we get better results by proper traction, without hurting the skin or macerating the tissues, by a slow method over a long period of time, than by force. Our cases which fail of reduction at the first sitting are placed upon traction and are reduced in two or three weeks. The ease with which that head will slip into the rudimentary socket is very suggestive. Therefore, I am more and more inclined, as time goes on, except in very small babies, to put all cases up in traction and to produce stretching slowly, over a period of two or three weeks, before attempting any operative manipulation.

Dr. Charles A. Parker, Chicago: I want to express my personal appreciation of what Dr. Adams brought back with him. I think the rest of us, who did not take the trip, fail to appreciate the results. There is no doubt that he has more knowledge of the operation and treatment than he has given us in this brief paper. What I would like to ask is the age limit, higher and lower, of the cases treated by Dr. Denucé.

A word regarding the after-results: Five years of treatment will not allow us to determine what the final results will be on the head of the femur. I was

talking to Dr. Ridlon just before coming East and, as far as I could see from Dr. Denucé's method, the difference in the replacement of the head was that Dr. Ridlon keeps his great big fatherly thumb in front and on the head of the femur and he knows pretty nearly all the time where the head of the femur is. I do not know whether that is very much different from Dr. Denucé's method where he speaks of keeping the fingers behind and around the head of the femur. Dr. Ridlon wanted that particularly mentioned, that he keeps his thumb in front. He was one of the earlier members to reduce hips with a minimum amount of injury to the head, but with difficult cases you see Dr. Ridlon sweat as hard as any of the rest of us before he can get the head in, even when extreme force is used.

Dr. V. P. Gibney, New York City: I have enjoyed this discussion very much. I recall our early experiences and recall the traumatisms that followed manual reductions. I can recall one or two amputations after reduction and one or two deaths. I suppose, as these gentlemen have said, you who are in the habit of putting great force and pulling on the abductors feel that that is the proper method. We are apparently satisfied with our results and then after a while we begin to take stock and find that the head is not where we thought it should be, over the edge of the acetabulum. The parents are satisfied and the children walk with a minimum amount of shortening.

I did not hear Dr. Adams' paper. It seems to me we are still struggling with that deformity and still looking for good end-results. Dr. Gaenslen wrote me that they were looking for end-results, but I had to give him the same answer that I gave to the lady twenty years ago or more, who asked me if I could show her end-results. I told her that I could show a few. Then she asked me if I could tell her the name of the man who had done more of these bloodless operations. I told her he lived in Vienna. She had taken her child to the senior orthopaedic surgeon in Chicago and he had reduced one hip but was disappointed in the result of the other. Then she took her to the other man who said, as many of us do, that he did not get the case soon enough. I saw that same patient several years later, coming out of the dining-room in a Southern hotel, still limping on the left hip. I am not talking in the way of criticism; I am trying to be perfectly fair.

I have enjoyed this discussion very much.

Dr. Z. B. Adams, Boston (closing his part of the discussion): I cannot answer all the questions but I will do my best to answer some. Dr. Hibbs asked about the number of cases. I tried as hard as I could to run that question down. In Bordeaux and the territory from which these cases come there were five million people at the last census; in New York there are fifteen million. I wrote to Dr. Hibbs and he sent me the number of hips that he had reduced. I also wrote to Dr. Gibney and he sent me the number of cases that had been reduced in the Hospital for Ruptured and Crippled. There were nowhere near the number of cases that they had in Bordeaux; nevertheless, this hospital in Bordeaux is very old. The hospital is 150 years old and it probably takes care of all the cases, or nearly all the cases, that are found in that region, so that I do not know that we can compare it. Then we know that congenital dislocation of the hip is somewhat of a racial disease. It is unknown among the colored people and is very frequent among the French people. That does not answer the question.

About torsion, in this method I described, osteotomy of the shaft was not done. Prof. Denucé showed me eighty cases of end-results after three years after the plaster had been removed and he showed me none in which he had done an osteotomy in the mid-shaft. In most of the cases he does not do an osteotomy but allows the torsion to take care of itself. Now the surgeon's hands, after pushing the head forward (Dr. Hibbs spoke of his wedge), pull the muscles in between the head and the side of the hip bone and prevent the head from locking on the back edge of the acetabulum. He uses manual reduction in all of the cases.

I might answer Dr. Parker's question about the age. Dr. Denucé has reduced double cases in children up to ten years, but he does not expect to get good results in the older cases. The head has been deformed for too long a time. The after-results show 80 children with excellent functional results. He puts stress upon the after-treatment. It is not only the reduction and the gentleness that must be used in the reduction, but the important thing is the after-care, and he says that one of the greatest dangers after you have reduced congenital dislocations of the hip is the surgeon; that when you take the plaster off at the end of a month the hip may slip and the head get out of position. Therefore he leaves them alone and does not take the plaster off. He lets them alone for six months. I saw x-rays showing that during the six months the acetabulum is made deeper.

Dr. Nathan asked about hips slipping out after reduction. They do occasionally slip out, but I think the all-important thing is to be sure you put the head in. I have x-rays showing that it is possible to lock the head back of the socket, not in it; but when you take the x-ray in another plane, the head is found to be in another plane, back of the acetabulum. Therefore, when you take the plaster off it drops right back.

Dr. Nutt's question about intra-articular pressure I cannot answer. I do not believe there is as much pressure brought on the femur by moving the thigh in the air as there is if the thigh carries the whole body weight. I do not know whether that answers the question.

About spontaneous dislocations and dislocations long afterwards, Professor Denucé has had one or two cases dislocated long afterwards and he simply re-reduced those cases and went on just as though they were primary dislocations.

Now this method, although Dr. Freiberg does not think so, is really worth while. It is an easy way of reducing hips, and difficult hips. Dr. Sayre's suggestion that we are caressing the muscles is very good. You do not hammer them; you do not pound them; you simply stroke them. You get the thigh so it lies at right angles before you attempt reduction, and with little children that is possible. It takes from fifteen to twenty minutes to reduce a hip. Some of the men will substantiate that statement who have tried to do it under my direction. Dr. Ober is here and he did it.

I think that, in brief, is enough to say. There is a good deal I could describe, and there are various tricks to use to get the child to use the leg. A child walking in plaster does a great deal of damage. The head is cartilaginous, and if you put the weight of the child and the weight of the plaster on the head you may crush it and do a great deal of damage. We endeavor to get the hip so that it is almost functionally perfect,—that is, that the muscles have come back and are strong before any walking. This method prevents atrophy of the contracted gluteal muscles and the other muscles

of the thigh. In some cases there was some difference in the size of the thighs found in the end-results.

DR. A. H. FREIBERG, Cincinnati: I think I must have been misunderstood. I do not think I said that this method was no good. I simply thought the x-ray evidence which we saw was very much like what we have been seeing in our own experience.

DR. Z. B. ADAMS, Boston: I could not show you functional results. All I could show you were x-rays. The results are functionally good—practically perfect in every case.

DR. W. J. MERRILL, Philadelphia (closing his part of the discussion): In addition I should like to bring a little emphasis on the after-treatment which Dr. Davis always used. In the after-treatment he used his braces to maintain abduction in a position required by the individual case. He kept the leg in abduction until the roof of the acetabulum was sufficiently formed to maintain the head in position.

THE REPORT OF THE COMMITTEE FOR THE INVESTIGATION OF THE BEST METHOD OF TREATMENT FOR CONGENITAL DISLOCATION OF THE HIP.*

JOEL E. GOLDTHWAIT, M.D., BOSTON,
Z. B. ADAMS, M.D., BOSTON,
DE FOREST P. WILLARD, M.D., PHILADELPHIA.

THE committee that was appointed in 1920 to report upon the best methods of treatment for Congenital Dislocation of the Hip, and which made a preliminary report at the meeting of the Association last year, desires to report further, as follows:

A considerable number of cases has been studied, coming from a fairly large number of individual surgeons who have been trained in different schools, so that the material studied is probably as fairly an average of the work as it is being carried on today as can be obtained.

It is obvious at once that the anatomic conditions of depth of acetabulum, shape of neck and head of the femur, as well as the axis of the epiphyseal cartilage underlying the head of the bone, vary within wide range. That these features are of important consideration in treatment, and especially in the prognosis, there can be little question. It is urged that this part of the study of the cases, both before and after operation, be given more consideration.

In the cases which have been presented for study, the feature that perhaps attracts the most attention is the large number in which the head of the femur in the later pictures is either destroyed or very much misshapen, where the earlier pictures showed little if any malformation. This is so striking that to find cases in which the bones at all approach normal is by no means easy. That this is probably due to the violence used in the manipulation seems fair to conclude, and this opinion is strengthened by the fact that the proportion of destroyed or badly distorted bones is greater where the manipulative method involves much force than with those which are less violent.

This was obvious in the very early part of the study, and for that

*Read at the meeting of the American Orthopedic Association held in Washington, D. C., May 1-3, 1922.

reason was mentioned as a caution in the first report of this committee which was made last year. Since then the conviction has been strengthened so that this year the committee feels justified in making more explicit recommendations.

The committee is fully aware that many of the cases in which there is a badly damaged head of the bone, have very good function in the joint, but there is probably no disagreement that this is in spite of, rather than because of the anatomic disability. That so many have good hips is fortunate, but even the most ardent advocate of a method would hardly claim that a distorted bone is to be preferred to a well rounded one resembling that which Nature adopted as her normal.

In the beginning of the treatment of this condition, most of the methods involved the use of much force or, in the open method, involved extensive incisions with much damage to tissues. Since then the tendency has been to use less and less violence, but to make the reduction follow a better understanding of the mechanics of the hip-joint. In certain positions, to replace the bones requires the use of much force, and must damage tissues. In other positions, following the positions of physiological relaxation, replacement is relatively easy.

The methods which seem to best meet the requirements, and from which, once the methods are understood, we should expect the most perfect anatomical, as well as functional results, seem to the committee to be the method used and described by Dr. Ridlon, and the method devised and so extensively used by Professor Denucé of Bordeaux.

Probably in no method will there fail to be results that are not good, but it seems to the committee that on the basis of common sense, as well as scientific reasoning, the methods here mentioned will show fewer of these than with the other methods of which the committee has knowledge.

Of the machine manipulations, it seems to the committee that the appliance devised by Dr. Hibbs is least objectionable, and as a matter of fact is not wholly unlike the methods mentioned above, except that the forward movement of the head, once it has been placed low down, is accomplished by the machine instead of by the hand.

Correspondence

TUBERCULOSIS IN CHINA

The following letter, written from China in May, 1922, by Dr. Brackett, to the readers of the JOURNAL, arrived just too late to be inserted in the July issue, and is, therefore, printed now, although Dr. Brackett has already returned to the United States.

In a note which accompanied the communication Dr. Brackett says, "I can freely say that I have learned more how to take a broader view of many problems than I ever have before. No one who has not been here can form an opinion of the problems which confront these men, and neither can one form an adequate idea of the really fine way in which they meet them, handicapped to a tremendous degree. I am only hoping that this letter will reach you in time. It should if the disturbances which this country is undergoing do not delay transportation too much." The letter follows:

Pekin, China.

To the Readers of the JOURNAL:

It is of no special interest to those who have followed, even in a superficial way, the general medical conditions in China, to emphasize the fact that tuberculosis of bone forms a very large part of the surgical practice of the different hospitals and mission posts. The situation is not particularly different from that which existed in the United States twenty-five or more years ago, when a large part of the clinic of any children's hospital was comprised, not only of tubercular bone diseases, but also of these cases in the advanced and suppurating stages. Owing to the fact that the people in these countries are not yet educated to apply for relief in the early stages of these conditions, many of which are insidious, it is rare that they come under the notice of the surgeon until in advanced stages, and it is therefore distinctly true that this group, comprised of the later periods, forms a very large part of the work in the clinics, and it also presents the most difficult problems, and these must be met in some way with facilities which exist at the time and the place. The interesting feature of this situation is in its demonstration of the fact that it is always necessary to adapt principles of treatment to the equipment, both as regards personnel and physical equipment, which may be found at the time and at the place rather than to insist on methods of applying the principles: in other words, to apply the principles to the economic conditions. A study of the problems which are met by the men in this country, working with the handicap of limited personnel, meagre equipment, and of either apathy or superstition on the part of the patients, illustrates how much more important it is to have a thorough understanding of the principles of treatment and of the results which may possibly be obtained by their application, than of definite and fixed methods of applying these principles.

It also emphasizes the greater necessity of having in mind the probable, or at least the desired ultimate result, and this is particularly true when applied to those destructive processes which are found in bone tuberculosis. It also emphasizes the necessity that the original aim should be for the permanent and secure, rather than for a compromise, result, which may perhaps take the patient over a few years, but which will not stand the greater strain of later life, with the increased physical activity, increased weight, etc. In these countries it is very evident that the economic conditions under which the patients are placed necessitates the cutting out of the long period of conservative treatment, including the long period of convalescence, and of obtaining an ultimate and secure result in the shortest possible period. Many times this will be at a sacrifice which might be considered unjustifiable in many cases where conditions are more favorable. One must, therefore, resort to radical, which will be operative, measures, in these cases where under more favorable suroundings and conditions it has been the custom to spend many years in conservative treatment and where it is a matter of experience that this ultimately can be obtained. This is most evident, and at the same time it is most difficult to apply this principle to the treatment of these cases in children, and it not infrequently becomes a necessity,—in fact, there may be no choice, sometimes,—even to sacrifice a part. One should be able to derive a lesson from this, which may sometimes be applied when working under conditions far more favorable, as, for instance, in the United States,—namely, to have in mind, even in the early stages, the probable and desired end-results, as well as the principles of treatment, and to determine by what method this result may be most quickly and safely obtained. One cannot be satisfied to have as an ultimate result, after many years of treatment of an extensive destructive lesion, a joint which is unstable and which will demand a radical treatment after some few years of attempted use, when perhaps some earlier and more radical measures would have given the same result and without the long period of restriction and seclusion. The indirect but important and sometimes serious results of long conservative treatment are too often lost sight of until too late, and the lesson which intrudes itself while working among these cases and under the conditions which are found here, is the need of clear foresight, looking toward final results, trusting by the early recognition of these facts, to arrive at a decision which will not have too much the flavor of a compromise.

E. G. Brackett.

News Notes

Dr. W. A. Cochrane, F.R.C.S., Edinburgh, who has been practising in Boston, Massachusetts, for the past year, has accepted the position of Clinical Tutor at the Edinburgh Royal Infirmary, Edinburgh, Scotland.

BRITISH ORTHOPAEDIC ASSOCIATION.

SUMMER MEETING HELD AT SIR WILLIAM TRELOAR'S HOSPITAL FOR CRIPPLED CHILDREN, ALTON.

The summer meeting of the British Orthopaedic Association was held on May 26th and 27th, 1922, under the chairmanship of Sir Robert Jones, about 40 members and visitors being present.

The meeting opened with a demonstration of lantern slides at the Cinema, Alton, illustrating the methods employed at Sir William Treloar's Hospital in the treatment of non-pulmonary tuberculosis, with examples of patients before and after treatment. Some seventy slides were exhibited. The Hospital is the largest in the British Empire for the treatment of surgical tuberculosis; there are 314 patients under treatment. The treatment is called "conservative" and defined as "the adoption of all measures which tend to improve the patient's general health, increase his powers of resistance, and preserve and restore the part attacked." Sir Henry Gauvain then showed a cinema film of the application of a high plaster jacket for cervico-dorsal caries. A cinematograph film of a normal man walking and of several men wearing artificial limbs walking under the same conditions was shown by Mr. Elmslie. This film was taken with an ultra-rapid cinematograph at the rate of 160 pictures per second and the movement analysed by slowing the film to about 10 pictures per second. A short account of the results arrived at has already been published in St. Bartholomew's Hospital Journal for September, 1920, and in Mr. Muirhead Little's "Artificial Limbs."

The Association then visited Sir William Treloar's Hospital and College for Crippled Children, which was established for the intensive education and technical training of crippled boys between the ages of 14 and 16 years. The period of training is three years. Any type of cripple is admitted provided (1) he has the use of both hands, (2) that he is so physically defective that unless he receives specialized instruction in occupations suited to his limitations, he will be unable to earn his living. The methods employed have been extremely successful, and on completion of training the lads are capable of earning

their own living on equal terms with healthy competitors. The standard of work performed is so good that little difficulty exists in obtaining employment. The instruction is essentially practical, and the chief trades taught are leather bag, case, and trunk making, tailoring, boot making and repairing. The crippled boys are taught by special instructors, who have themselves been practical workmen, and their education is provided by selected teachers.

Cases were shown illustrating the mechanical methods of treatment in spinal caries and hip disease, comprising:

1. Spinal board for immobilizing and hyperextending cases of spinal caries, mounted on special stand for convenience in nursing.
2. Wheelbarrow splint for spinal caries with moderate deformity and psoas abscess or spasm. (Gauvain.)
3. Swinging back-door splint for correcting moderate residual deformity in spinal caries. (Gauvain.)
4. The so-called "Marconi" apparatus for correcting advanced deformity in spinal caries. (Gauvain.)
5. Tilting stand for paraplegia and other conditions. (Gauvain.)
6. High plaster jacket.
7. Celluloid spinal jacket.
8. Treatment of hip disease by webbing extension.
9. Treatment of hip disease by plaster extension. (Gauvain.)
10. Treatment of hip disease by plaster extension and immobilization combined. (Gauvain.)
11. Condylar clamp extension apparatus. (Gauvain.)
12. Plaster spica.
13. Winged celluloid hip splint.
14. Ischio-condylar metal splint (Gauvain), expansible and ambulatory.

The wards at Alton are arranged in two semi-circular blocks with ten radiating wards in each semi-circle. On the lesser circumference the wards are united by a 14-ft. curved balcony, and between alternate wards is a wide solarium, so that in inclement weather patients may be treated in the wards with open windows, during showers under covered balconies, and in fine weather in fully open, but sheltered, solaria especially designed for sun treatment.

All patients are educated while receiving treatment by specially selected teachers approved of by the Board of Education. There are 13 such teachers, working double shifts of three hours each. Each patient receives 1½ hours instruction both morning and afternoon. In the morning ordinary school lessons are taught; the afternoons are principally devoted to manual work. A piano is provided in each ward. The first approved English Hospital Nursery School for children under the age of five was founded at Alton, and special methods have been devised for instructing the patients. In the spinal ward for recumbent patients the lessons are lowered on to the patients by special apparatus.

In the centre of "A" Block is the Treatment Block, in the centre of "B" Block the Administrative Offices. The beds, stands, and cots on which the patients are treated have been specially designed for convenience in nursing the patients in the institution. All splints, appliances, and boots are manufactured in the institution.

The Hospital at Alton is situated on the southern slopes of the chalky North Downs at an elevation of 500 ft. above sea level. The estate comprises 130 acres and has its own poultry farm (100,000 eggs produced annually) and vegetable garden. The estate at Hayling Island is 60 acres in extent.

The marine branch of the Hospital at Lundy Point, Hayling Island, was visited on Saturday morning, May 27th; it accommodates at present 50 patients. The site was specially selected after the whole south coast of England had been explored. The Pavilion in which the patients are treated was specially designed for the work, and is so constructed that from the Sister's office patients in the ward, on the balcony, solarium or beach, are under constant supervision. At high tide the sea reaches the solarium, at low tide there is an extensive sandy beach. The hospital property abuts on a mile of private beach, which is available for treatment. The estate is situated at the extreme southeast corner of Hayling Island, remote from towns, to allow of undisturbed treatment. The coast is flat and sandy, there are no rocks or cliffs to interfere with the movement of patients. The rainfall is the lowest on the south coast of England; there is abundant sunshine, the heliotherapeutic value of which is assisted by the reflection of luminous and actinic light from the sea, which completely surrounds the hospital. There is wide tidal excursion. Absence of trees and rivers causes a clear atmosphere and freedom from mists. The South Downs to the north shelter the institution from cold winds. Heliotherapy is practised at both Hayling and Alton. Sea bathing at Hayling is possible and practised for eight months in the year, and paddling all the year round. In the winter sheltered coke braziers on the beach supply radiant heat to nude ambulant patients; recumbent patients are treated on electrically heated beds. Patients may thus be exposed to the air and sun throughout the year.

Patients are treated at Alton or Hayling, or at both institutions, as their requirements indicate, and are transferred by the institution's own motor ambulances. Treatment at Hayling especially induces very high metabolic activity and necessitates a very liberal diet. Very young or very weakly patients are not suitable for this marine treatment, which is also contraindicated in certain conditions, such as intestinal tuberculosis.

The effect of open air, heliotherapy, and balneotherapy have recently been very fully investigated at Alton and Hayling by Professor Leonard Hill and other workers of the Medical Research Council, who have shown that exposure to the open air very rapidly increases and maintains the basal metabolism of the patients, and that sea bathing still more rapidly and markedly produces the same effect. The technique employed in heliotherapy is fully described in "Tubercle," June, 1920. Professor Leonard Hill gave the Association a brief account of his investigations and conclusions.

In the practice of heliotherapy ambulant patients are first permitted to paddle, then are sprayed, and only later is complete immersion allowed. Recumbent patients are first sprayed, later carried into the sea in specially designed cradles. The period of immersion is carefully timed and only permitted to the degree of producing a brisk subsequent reaction. After bathing, the patients' feet are immersed in hot water, and hot drinks are given to produce rapidly the desired reaction. In selected cases very rapid improvement, both in the general condition and in the local lesion, ensues, the effect on sinuses being especially marked. The patients bathe in the open sea in a netted-in space, and are always accompanied by porters in waders.

INSTRUCTION IN HELIOTHERAPY.

In order to acquaint physicians with this branch of therapy and its technique Dr. Rollier and his colleagues at Leysin, Switzerland, instituted in 1921 a short course of lectures and demonstrations to which the medical profession are made welcome. This course was repeated in 1922 from the 15th to the 19th of August. No charge is made to those who participate.

The program for 1922 consisted of the following:

The Scientific Fundamentals of Heliotherapy, Physical and Biological Study of Light, } Dr. A. Rosselet.

The Present Conceptions of Tuberculosis, Dr. Lichtenbaum.

The Practice of the Solar Cure for Tuberculosis. With Lantern Slides and Demonstration of Clinical Material. Dr. Rollier.

X-ray Diagnosis of Osteo-articular Tuberculosis and Radiographic Control of the Clinical Results of Heliotherapy. Dr. H. J. Schmid.

Heliotherapy of So-Called Surgical Tuberculosis and its Clinical Results. (Pott's Disease, Coxalgia, Arthritis, Adenitis, Peritonitis, etc.) Dr. Rollier.

Heliotherapy and Joint Function. Dr. Mieville.

The Work Cure and the Future of Convalescents. Dr. Rollier.

Preventive Heliotherapy, Lantern Slides. Dr. Rollier.

The Adjuvants of Heliotherapy (Radiotherapy, Artificial Phototherapy). Dr. Amstad.

Heliotherapy of Non-Tuberculous Affections, with Presentation of Patients. Dr. Amstad.

Demonstration of Orthopaedic Apparatus Used in Heliotherapy. Dr. Amstad.

Heliotherapy and the Skin. Dr. Leuba.

Visit to the Heliotherapeutic Establishments of Dr. Rollier and Presentation of Cases. Dr. Rollier, Drs. Amstad, Alexandrowsky, Giauque, Lichtenbaum, Mieville and Schmid.

Visit to the "École au Soleil" and Demonstration. Dr. Rollier.

Very interesting excursions were arranged after the course. These included St. Moritz and the picturesque line: Diablerets-Sepey-Aigle. This course will be repeated in August, 1923.

Current Orthopaedic Literature

CONGENITAL DEFECTS.

PATELLA BIPARTITA. Hans Blencke. *Zeitschr. f. Orthop. Chir.* B. XLII., H. 5., S. 291.

Only a limited number of cases of accessory patella, patella bipartita, or supernumerary sesamoids on the patella have been reported in literature. The author adds two cases to those reported. Both have followed trauma and the patients have claimed compensation on account of the "fracture of patella." The differential diagnosis is, therefore, essential and important.

Patella bipartita is bilateral. Therefore, in all doubtful cases the injured knee should be compared with its fellow, to exclude traumatic fracture, calcareous bursitis, or spontaneous fracture which occurs in neuropathic bone affections of tabes, progressive muscular atrophy, etc.

The sesamoid of the patella is situated at the lower end or at the upper outer quadrant of the patella. The patella bipartita may be single or may consist of two or more fragments, all of which would give the form of the piece separated from the patella. The line of division from the patella is always smooth, sharp, without any corrugations, as could not be expected in any form of fracture, even if it were bilateral and painless as in the tabetic individuals.—*A. Gottlieb, M.D., Los Angeles, Calif.*

MADELUNG'S DEFORMITY OF THE WRIST. Brandes. *Ztschr. f. Orth. Chir.*, 1921, XLII. 1 H., page 20.

Ten years ago the author reported the cases of two sisters, 18 and 24 years of age, whose deformity had been inherited from their father. In a recent examination, it was found that the curve and expansion of the radius and the obliquity of its epiphysis had increased. The author considers that the primary condition is due to a disturbance of the zone of growth of the radius, with the bending of the radius as secondary to this. The disturbance of growth of the epiphyseal cartilage is congenital. In favor of this view are the occasional hereditary and familial occurrences and the simultaneous appearance of metacarpal brachydactylism. It is possible that the condition is the result of late rickets. The author considers Sprengel's conception excellent for other cases, i. e., that the torsion of the radial shaft and its volar and ulnar concave bending of the radius is primary.—*Armin Klein, M.D., Boston.*

CLUB FOOT OPERATION. Gaugele. *Arch. f. Orth. u. Unfall-Chir.*, 1921, xix B., 3-4 H., page 455.

The author reserves this operation for cases where, after two or three redressments in plaster, the adduction of the fore foot persists, and cases where the result is good except for the adduction of the fore foot, especially of the big toe. The big toe can, of course, be passively adducted, but in that case the outer border of the foot sinks downward, i. e., the base of the fifth metatarsal. If the outer border of the foot is pressed upward, the big toe becomes plantar flexed and adducted again. This is due to the fact that the outer border of the club foot is longer than the inner; the base of the fifth metatarsal opposes any straightening of the convexity of the outer border. For this reason the author removed, in several cases, the base of the fifth metatarsal and freshened the adjacent cuboid to get union. Incision was made lengthwise 1 cm. above sole. The operation immediately removes the hindrance to correction. The foot is put into a plaster cast, with the fore foot in strong abduction, with the big toe completely held in place by the plaster. The results are good, without any damage. The author has not always obtained union of the fifth metatarsal and cuboid because he removed too much of the base of the metatarsal.—*Armin Klein, M.D., Boston.*

OPERATIVE TREATMENT OF CONGENITAL ELEVATED SHOULDER ACCORDING TO KOENIG. Grauhan. *Archir. f. Orth. u. Unfall-Chir.*, 1921, xix B., 3-4 H., page 408.

Report of a case of a girl, 17 years old, with double-sided elevated shoulder, with lack of the lower parts of the cucullaris muscle. The left side was higher than the right. There was union of the transverse processes of the second and third dorsal vertebrae on the left to the medial border of the scapula. The upper part of the left scapula had grown toward the outer side, upward and forward, so that the supraspinous part was prominent at the front of the neck, and it was possible to raise the arm only 25 degrees above the horizontal plane. Because of this lack of power to elevate the arm and because of increasing deformity operation was performed. It was found that the lateral part of the scapula, with the condyloid process, had been separated from the medial part and drawn aside. The lower medial part, whose union with the vertebrae remained preserved, served to hinder any rising up without limiting motion about the ventrodorsal axis. The operation, which was essentially according to Koenig, does not interfere much, and does not damage the existing musculature of the trunk and shoulder. The cosmetic and functional result was so satisfactory that the operation for the treatment of elevated shoulder blade is worthy of repetition.

The operative procedure is as follows: The incision was to the lower half of the medial border of the scapula. The periosteum was split and elevated. The medial span of bone (wide as a finger) remained united to the dorsal vertebrae. The lower corner of the lateral part was drilled through and then the whole lateral part was very easily dislocated downward about three or four cm. The medial and lateral parts were then united by two wire sutures. Through the

hole in the lower corner of the scapula, according to Koenig's method, a strip of muscle fascia was drawn.

Gymnastic exercises and medico-mechanical postoperative treatment followed.

A short time after the operation the left arm could be elevated to the perpendicular plane.—*Armin Klein, M.D., Boston.*

CONGENITAL ANATOMICAL DEFECTS OF THE SPINE AND RIBS. James Warren Sever, M.D., *Boston Medical and Surgical Journal*, June 15, 1922.

Dr. Sever has given us an exhaustive anatomical study covering such matters as theories of ossification, numerical variation, and defects of the vertebrae and ribs in the cervical, thoracic, and lumbar regions of the spine. There is also a statistical list of anatomical findings and a report of cases. The paper is illustrated by 40 excellent photographical reproductions of the surface anatomy and of the bony structures as revealed by the x-ray. The conclusions quoted below can scarcely be improved.

"It is obvious, even after studying such a large series of cases, that no very definite conclusion can be reached as to the cause of such vertebral and rib defects. One can only fall back on the original morphological and embryological theories, and can be content to exhibit these cases as examples of such developmental faults as nature saw fit to impose. That many of them cause serious structural defects and scoliosis is not questioned, and the problem can be met, at best, only by such external corrective methods as one can employ."—*H. A. Pingree, M.D., Portland, Me.*

A METHOD OF PROLONGED RETENTION IN THE TREATMENT OF EQUINO-VARUS IN THE NEW-BORN. Lucien Michel. *Revue d'Orthopédie*, January, 1922, page 65.

If treatment of club feet is begun at birth the condition can be completely cured in more than a third of the cases and the deformity can be ameliorated in every case. Unfortunately, however, the results are rarely definitive and the real problem is to maintain the correction and prevent relapse.

The objection to most forms of braces for holding the feet is that they are rigid, and since they must be worn many months they cause atrophy of the muscles. Another objection is that they have their point of support on the same leg as the foot which they are supposed to hold, and on this account it is impossible to prevent inward rotation. To obviate these difficulties Nové-Josserand has devised an apparatus of spring and aluminum which has a point of support on the opposite side. This idea is not absolutely new, since Neil and Heusner have used braces with support on the opposite side.

The foot piece is cut out of aluminum from a paper pattern made from a tracing of the foot. It has flanges to enclose the heel and one flange coming up around the mesial side of the foot anteriorly. The two foot pieces, right and left, are then set at the abduction angle at which it is desired to hold the feet and a bar of spring steel fastened on to the soles of the braces joining them together. This steel spring is about 1 cm. in width and 15 to 20 cm. in length, and is fastened to the soles of the braces by being passed through slits in the metal, and held by bending down a flange on the outer edge of each brace. It is easily detachable from the braces.

The method of applying the apparatus for double club foot is as follows: The sandal-shaped aluminum braces are strapped on the feet, then the steel spring is inserted joining the feet together. Finally, in order to produce the required abduction of the feet and outward rotation of the legs, a bandage is applied encircling both legs as a whole from the knees down about half-way to the ankles, binding the legs together. If it is a unilateral case the brace on the normal foot has a bar running up the inside of the leg which prevents valgus deformity of the good foot. In rebellious cases the foot piece is made in two parts, a heel piece and toe piece, the latter pivoting on the former in such a way that abduction can be increased when desired.—*William Arthur Clark, Pasadena, Calif.*

PARALYSIS.

POST-DIPHTHERITIC PARALYSIS. T. J. Elterich. *Pennsylvania Medical Journal*, April, 1922.

A report of two cases of post-diphtheritic paralysis involving the heart or diaphragm. In one, death may come very suddenly. In the other, the general weakness may come on more slowly. The prognosis is very bad. The occurrence of paralysis is not prevented by antitoxin, but the occurrence seems to be less common the earlier the antitoxin is given.

In a case of the second group above, recovery was obtained by the use of very large doses of strychnine nitrate subcu. This case received a total of 6 grains in 10 days without any signs of twitching of the muscles.—*L. T. Brown, M.D., Boston.*

THE DIAGNOSIS, PROGNOSIS, AND EARLY TREATMENT OF POLIOMYELITIS. Robert W. Lovett. *Jour. A. M. A.*, May 27, 1922, page 1607.

It is common knowledge that many cases of poliomyelitis are overlooked in the early stages, being incorrectly diagnosed as all sorts of febrile affections, and the diagnosis cleared up only after the paralysis develops. Also, typical cases may occasionally occur without any manifestation whatever of systemic disturbance in the way of fever, malaise, or respiratory or digestive upset. Laboratory diagnosis can be made in the early stages by spinal tapping. The cerebrospinal fluid is increased, clear, and a few polynuclear cells may be present (virus absent). At times experts are unable to differentiate the poliomyelitis from tuberculous meningitis by spinal tapping. The author points out that tenderness should at once arouse suspicion.

Dr. Lovett discusses the pathology and points out that initial changes occur around the blood-vessels of the spinal cord, where a marked infiltration takes place shutting off their supply of blood. Anemia or necrosis of the anterior horn cells may result. The whole effects of the condition are localized in the motor cells of the anterior horns of the spinal cord. The result then must be (1) a loss of power in the muscles supplied by the cells in question; (2) no loss in sensation because the cells in the posterior horns are not involved

in the process; (3) reflexes are lowered in the part involved. Thus the disease picks out motion alone and leaves sensation untouched. Drugs are of no value in the treatment. Keep the patient quiet mentally and physically. No stimulation; no massage; rest as long as tenderness is present. If there is extreme tenderness, allow the patient to lie in the position which is most comfortable. The outlook for recovery in the abdominal muscles is poor. The main treatment is to prevent deformity and restore function. The former is accomplished by means of posterior wire splints or posterior casts; the latter by massage and muscle training. Massage does not improve muscular power, but improves nutrition, circulation, and muscle tone. If the exercises are not carefully controlled, the patient is sure to use the strong muscles instead of the weak ones, to develop these, and thus to make the muscular balance still worse. Weight-bearing exercises, with casts or braces, such as walking to any extent in the first year after infantile paralysis, is apparently attended with risk and is followed in many instances by a change from partial to total paralysis.—*Voigt Mooney, M.D., Pittsburgh.*

DELTOID PARALYSIS AND ARTHRODESIS OF THE SHOULDER-JOINT. George F. Straub. *Surg., Gyn., and Obstet.*, April, 1922, page 476.

Report of an operation for arthrodesis of the shoulder-joint for paralysis of the deltoid.

The main points of the operation are 1st, most thorough removal of synovialis; 2nd, most radical removal of all cartilage down to spongiosa; 3rd, strict avoidance of all foreign nonabsorbable fixation and suture material (he uses a tibial peg); 4th, the use for fixation purposes of the upper part of the biceps tendon which is put into the intertrochanteric groove, from which has been lifted up a shell of bone.

Immobilization in a plaster cast for 12 weeks. The position in which the arm is put is with the humerus at about right angle abduction to the body, viz., the external border of the scapula from 80 to 110 degrees to the axis of the humerus.

He shows pictures of one case 12 weeks after operation.—*L. T. Brown, M.D., Boston.*

FORMS OF ARTHRITIS.

CHRONIC INFECTIOUS ARTHRITIS: STATISTICAL REPORT WITH END-RESULTS. Frank Billings, George H. Cole, and William S. Hibbs. *Journal A. M. A.*, April 15, 1922, page 1097.

A long article impossible to abstract. Certain points of interest may be mentioned.

The article is a report of the treatment of 411 patients with chronic arthritis. The writer says that a study of the group justifies the view that the morbid tissues, both hypertrophic or proliferative, and atrophic or degenerative, are secondary to the primary reactions of the joint tissues due to the presence of infectious invaders or their toxins. The embolic mode of infection is the cause of the tissue reactions. General chronic infectious myositis with but slight joint involvement in the early stage of the disease was a clinical entity in this group.

The statistics of the group showed that the more acute the onset of infectious arthritis, the more favorable the prognosis for improvement and cure, and the more insidious the onset, the less favorable the prognosis for improvement or cure. Of a group of patients admitted within two years of the onset of their disease, 133 in all, 42 recovered and 36 were improved. Of 278 with a period of more than two years, 29 were cured and 106 were improved.

The statistics confirm the opinion that specific remedies in the form of bacterial antigens are of little or no value.

In conclusion the writer says that "the clinical investigation confirms and substantiates the present point of view of a majority of clinicians who have had the opportunity to make a careful investigation of chronic deforming arthritis, that it is primarily an infectious disease and that the infectious microörganisms which are the cause are usually strains of nonhemolytic streptococci of relatively low virulence, or occasionally strains of nonpyogenic gonococci or even other bacteria of mild pathogenicity.—*L. T. Brown, M.D., Boston.*

TWO CASES OF RHEUMATOID ARTHRITIS. A. Mackenzie Forbes. *Canadian Med. Assoc. Journ.*, May, 1922.

The first patient was a woman 56 years old who had had recurring attacks of sciatica since she was twenty. She entered the hospital with the left hip held in flexion of 35 degrees and the right one in flexion of 45 degrees. The hips were held fixed, but not ankylosed. A diagnosis of rheumatoid arthritis was made and the tonsils considered the source of infection. After their removal local dry heat was applied to the hips, massage and manipulations used, magnesium sulphate and iodine given, and the patient at the end of six weeks was "greatly improved and discharged to her home where she could continue treatment."

The second patient was a woman 38 years old, with a similar condition of her hips. No sources of infection were found. In this the author followed out a suggestion made several years ago by Dr. Pemberton, that in many of these cases a decreased sugar tolerance appeared to be the cause of the arthritic symptoms. A biochemical examination was made establishing definite evidence of diminished sugar tolerance and the patient was put on a dietary with almost complete restriction of the intake of sugar and carbohydrates. An improvement took place, but albumen and casts appeared in the urine, that only cleared up after a return to a more normal diet. Further report is not given.—*C. A. Parker, M.D., Chicago.*

AMEBIASIS OF THE BONES. Charles A. Kofoid and Olive Swezey. *Journal A.M.A.*, May 27, 1922, page 1602.

The authors carefully discuss in detail their observations relative to the ameba in the lesions of Ely's non-bacterial or second type of arthritis deformans. They speak of the connection between infection by endameba dysenteriae and bone rheumatism. Many instances of coincidence of amebiasis and a diagnosis of arthritis have come to light in the course of more than 15,000 stool examina-

tions. On the basis of the type of mitosis and of the number of chromosomes in the cell, the ameboid organisms in the bone marrow are amebas rather than ameboid human cells. They appear in all respects to be normal amebas, and the mitosis to be normal type. There is no structural evidence connecting them with any form of degenerating human cells in the lesions examined. The authors conclude that Ely's second type of arthritis deformans is amebiasis of the bone. The authors studied sections of the head of the excised femur. They found in this material ameboid cells which they interpreted as endameba dysenteriae.—*Voight Mooney, M.D., Pittsburgh.*

OPERATIVE TREATMENT OF ARTHRITIS DEFORMANS. A. Wollenberg. *Zeitschr. f. Orthop. Chir.* B. XLII., 5. H., S. 275, 1922.

The author's observations are limited to the lower extremities, for which he gives the operative indications. Only cases of the Volkmann-Virchow types of arthritis deformans and not progressive polyarthritic and neuropathic arthritis deformans are considered.

I. For arthritis coxae the indications are: 1—persistent pain and discomfort notwithstanding prolonged conservative treatment, and 2—excessive loss of hip function, which greatly interferes with walking.

Cases with pseudo-ankylosis in poor position may well be corrected by subtrochanteric osteotomy; forcible correction may result in sad consequences and had better be avoided.

Whenever mild rocking motion exists, the intra-articular procedure is preferable because markedly limited motion, even with good position of the femur, is invariably painful. The intra-articular operation should aim to restore motion of the joint in patients not exceeding 50 years of age. The loss of the restored motion in the course of years may necessitate an ankylosing operation later if the patient is young enough, while in the old and decrepit, operative interference is contraindicated anyway, and the patient should be helped by a brace.

An unavoidable indication for an arthroplastic resection of at least one hip is given in cases of bilateral coxitis deformans with extreme loss of function.

II. The only indication for knee operations is a sudden and typical locking, incarceration, of the knee.

The operation should be incomplete, *i.e.*, neither arthrodesis nor arthroplastic resection, but should aim only to remove loose bodies and such as may be adherent to the synovial membrane or attached to the bone surfaces and thus cause symptoms.

III. Ankle-joints are operated upon as conservatively as the knees, but the results have not been favorable. After removal of loose bodies and chiseling off of osteophytes from the tibia and astragalus, only very little improvement has been gained; the author, therefore, advocates an ankylosing operation, arthrodesis of the ankle-joint.

IV. In the foot, arthritic lesions, which are very painful, may be found most frequently in the astragalo-scaphoid joint. Resection of the joint with the purpose of correction of the flatfoot position is advocated.

The metatarso-phalangeal joints may present osteophytic growths which are very incapacitating and painful. They should be restored to normal by means of chisel and file under local anaesthesia.

The exostoses of the os calcis are operated upon only when they cause unbearable pain and are not relieved by properly shaped arch supports.

No case of arthritis deformans should be submitted to operation before an extensive course of conservative therapy, motion without weight-bearing, local heat, and other physical agents, has been instituted and faithfully carried out. —*A. Gottlieb, M.D., Los Angeles, Calif.*

CONTRIBUTION TO THE STUDY OF LATE HEREDITARY SYPHILITIC OSTEO-ARTHROPATHY OF THE SHOULDER. Miginiac and Cadenat. *Revue d'Orthopédie*, March, 1922, page 105.

The joints do not seem to be so frequently affected by syphilis as the bones, and of all joints, the shoulder is most rarely affected, judging at least from the small number of cases reported in literature.

The authors report a case of a boy of 13 who began to have pain in the right shoulder in March, 1921, following a slight fever. He cried with the pain four or five days, then a tumor on the shoulder became apparent and within a month the pain was gone, but the tumor persisted. The swelling was rather hard and about the shape of a leg of mutton. The superficial veins were dilated, the skin was hot, there were some swollen glands under the clavicle and a large soft one in the axilla. The humeral head appeared to be enlarged and could be moved enough to produce an anterior luxation without causing any pain, but active motion was very difficult. The first thought one had from the clinical picture was of sarcoma, but the roentgenogram showed no such growth. Except for slight decalcification and elevation of the periosteum along the external aspect of the surgical neck, the humerus was normal. There was an upward displacement of the humeral head, the space between the glenoid and head being widened. By elimination a diagnosis of syphilis was made and confirmed by finding some of the classical signs of hereditary lues in other parts of the body and by a positive blood Wassermann in the child and in the mother. In May of the same year a point of fluctuation appeared over the biceps from which 2 cm. of yellowish fluid was evacuated. No bacteria were present in it, but the fluid gave a strong positive Wassermann test. The swelling was reduced under a course of neo-salvarsan and gray oil.

Eight similar cases were found in the search through 132 articles on luetic arthritis and a résumé of these is given. From these cases and that of the authors the principal characteristics of hereditary syphilis of the shoulder are summarized as follows:

1. There is never any suppuration nor are there sinuses, the clinical picture resembling sarcoma or tuberculosis.
2. Swollen glands in the neighborhood of the joint.
3. The roentgenogram is practically negative, sometimes showing a little periosteal elevation or rarefaction of the bone.
4. Pain is moderate or absent and passive motion is free, luxation being possible sometimes.

5. No definite tenderness on pressure, but diffuse, rather hard swelling.

6. No muscular contracture, no bony deformity, no general cachexia as in malignant growths.

7. Surgical treatment is useless if not disastrous. Amelioration is rapid under treatment with mercury or arseno-benzol preparations.—*William Arthur Clark, Pasadena, Calif.*

A Case of Arthritis Deformans Juvenilis of the Hip. Yvernault. *Revue d'Orthopédie.* March, 1922, page 140.

A typical case of Legg-Perthes disease of the hip is reported. The deformity was quite marked but presented no unusual departure from the characteristic flattening of the femoral head and the limitation of abduction and inward rotation.

The patient was 21 years old and had never suffered any pain in the hip, but had complained of his right knee and limped in the right leg. When seven years old he had sustained an injury to this knee which was followed by acute swelling and necessitated immobilization for two months. This, however, had left no impairment of the joint and had caused no further trouble until the present limp began.

The fact that the deformity in the hip developed with practically no symptoms leads the author to conclude that its origin was probably congenital.—*William Athur Clark, Pasadena, Calif.*

FRACTURES AND DISLOCATIONS.

Traumatology of the Carpus. A. H. Bizarro. *Surg., Gyn. and Obstet.*, May, 1922.

Bizarro presents a detailed study of 123 cases of carpal injury occurring in his own practice and in the records of the Royal Herbert Hospital.

The distribution of the fractures is shown in the accompanying table.

	Cases	Single Lesion Cases	Associated Lesion Cases
Radius	8	0	8
Ulna	7	0	7
Scaphoid	106	68	38
Semilunar	20	2	18
Cuneiform	3	0	3
Pisiform	1	0	1
Trapezium	2	0	2
Trapezoid	2	0	2
Os Magnum	15	6	9
Unciform	8	4	4
Metacarpals	3	0	3

The mechanism of 55 scaphoid fractures without extrinsic synostosis is given as follows:

	Cases
Fall on the hand	41
Fall on the thumb	1
Sprain	4
Backfire of motors	3
Crushed wrist	2
Fall of weight on wrist	2
Boxing punch on wrist	2
	55

Diagrammatic profiles of the individual cases are given, with a discussion of the morphology of the carpal bones and the physiopathology of their fractures.

Treatment. "The upper carpal lesions usually require rest and the lower ones early movement."

Dislocations should be reduced when possible—in early cases—preferably under anaesthesia, and in case of scaphoid fracture rest maintained for four weeks. He advises plaster of Paris, with a change in two weeks to overcome the looseness from the shrinking of the tissues. The thumb should be included. Fragments that cannot be replaced should be removed, the semilunar through a palmar incision, and a lateral incision for the scaphoid. In extensive injuries he favors extensive removal, with early mobilization of the parts.

The fragments of the navicular seldom unite. "However, any of the above conditions, if seen early and early treated, usually lead to no disability at all."—*C. A. Parker, M. D., Chicago.*

METATARSOPHALANGEAL FRACTURES: REPORT OF TWENTY-SEVEN CASES. A. G. Bolduc. *Jour. of Indust. Hygiene*, April, 1922.

The writer advises an x-ray in all cases of injury of the foot or toes because it is his experience that the so-called contusion is very commonly a fracture.

The most common fracture in his series of 27 cases was the chip fracture, a simple or compound fracture of the distal phalanx. Next comes fracture of the proximal phalanx, and last the metatarsal.

The most common symptoms are continuous throbbing pain, tenderness to pressure, swelling, and, in some cases, localized oedema.

Treatment of chip fracture is always surgical, requiring an incision on the lateral side of the phalanx to relieve the tension of the extravasated blood in the encapsulated sac in the end of the toe.

Conservative treatment in phalanx is best. The disability period in these cases averaged 20 days, the longest being 38 days—6 cases.

Conservative treatment again in a plaster cast for metatarsal fracture is best. The period of wearing the cast is three weeks, but the disability extends about a week or two longer.—*L. T. Brown, M.D., Boston.*

PATHOLOGICAL FRACTURES. E. A. Codman. *Surg., Gyn. and Obstet.*, May, 1922.

This is a so-called "10-minute résumé" of this very interesting chapter in surgery. Dr. Codman outlines it under ten headings.

1. The literature,—referring to Eisendrath, in Keen's Surgery and the Registry of Bone Sarcoma.

2. Etiology. As secondary causes almost every human activity is mentioned, but he does not attempt to name them.

3. Pathology. Refers to Eisendrath's table:

1. Fractures resulting from bone fragility of local origin, tumors, cysts, etc.
2. Fractures resulting from bone fragility due to some general disease, neuropathies, senile changes, scurvy, etc.
3. Fractures resulting from idiopathic fragility of bone (osteoporosis fragilitas ossium).

4. The pathology of bone tumors. In the absence of a standard nomenclature he groups them under the following headings:

Osteitis fibrosa.
Bloodgood's giant-celled tumor.
Giant-cell sarcoma.
True osteogenic sarcoma.
Metastatic growths.
Multiple myeloma.
Tumors of tissues which normally occur in bones as well as in other parts of the body.
Chondroma.
Osteoma.
Rare tumors.
Tuberculosis, etc.

5. Differential diagnosis. He feels that exploratory incision should be the rule and that in the majority of cases, with proper sections, clinical history, and x-rays, an expert pathologist can make a differential diagnosis. A few border-line cases will still puzzle him.

6. Prognosis. With the exception of those caused by new growths it is a rule that pathological fractures tend to unite without much delay: with tumors and metastases they rarely unite.

7. Treatment. "The treatment is the appropriate treatment of the lesion which has weakened the bone. Exploratory incision and expert pathological opinion are the first steps."

8. Prophylaxis. It should be a general rule to splint all tumors of the large bones, especially the femur and the humerus, when tumors are found, until the tumor is otherwise disposed of. Ewing has long felt that every sarcoma of a large bone should be splintered and the patient kept in bed on account of the danger of metastases.

9. Theory. Codman raises the question whether fractures ever cause sarcoma, whether the granulating elements may not sometimes be set loose and lose their normal restraint limited to the formation of new bone. He leaves the question open.

10. Research. At present the so-called giant-celled tumors particularly are occupying the attention of the pathologists. In closing he makes a plea for the use of the Registry of Bone Sarcoma in registering every case that comes to the knowledge of the profession.—*C. A. Parker, M.D., Chicago.*

MECHANICS AND TREATMENT OF FRACTURES OF THE FOREARM. Paul B. Magnuson. *Journal A. M. A.*, March 18, 1922, page 789.

The writer points out the fact that in fractures of the Colles type and the chauffeur's type the injury that is done to the joint lies between the lower end of the radius and the ulna and the ligaments and fibro-cartilaginous substance which make up this joint. Lack of attention to this often results in lack of supination.

Fractures of one or both bones of the forearm above the wrist may be treated in semipronation or full supination as the two bones are at their maximum distance apart in either of these positions.

Fractures of the forearm must be classified according to their relation to the insertion of the pronator radii teres. Fractures above this insertion, because of the diverse muscular pulls and the fact that the nutrient artery may have been injured, causing extra hemorrhage and more danger of synostosis, should be treated surgically, as mechanical methods are less likely to give good results.

Fracture of the ulna above the middle is the result of direct violence and is often associated with dislocation of the head of the radius. The loss of the carrying angle caused by this fracture is very serious as regards function.

Treatment: non-operative ambulatory, which the writer believes is the cause of many of the bad results in forearm fractures; non-operative ambulatory and operative. Traction is best accomplished by being in bed with suspension of the forearm in a perpendicular position and the elbow flexed at right angles. Extension must not pinch the radius and ulna together. The finger and thumb must be free at all times. Pronation and supination should be under the control of the surgeon and not of the patient.

In the operative treatment the writer believes that lateral incisions are best as they involve no nerves, vessels, or tendons, which lead to adhesions. Ivory plates or screws are the best. The fingers and hand should be moved at the earliest possible opportunity.—*L. T. Brown, M.D., Boston.*

OPERATION FOR COMPLETE, IRREDUCIBLE, CONGENITAL DISLOCATION OF PATELLAE. Albert Mouchet and Jacques Durand. *Jour. de Chirurgie*, Sept., 1921.

Report of a case of this rare condition. Boy, seen at age of 10 years. Condition bilateral; no abnormality noted until he began to walk, at 16 months. No locomotor difficulty, except on stairs, to age of 6 years; since then walked with increasing difficulty, and with pain at knees. Seen by authors at age of 10 years. Patella of each knee very small, lying over external surface of external condyle, in plane at right angles with normal position; irreducible, but freely movable. Tibial tubercles displaced well to outer side of normal site. Free passive motion at knees, with even more than normal flexion; some loss of active extension. Positive Wassermann test.

Operation consisted in freeing a tongue containing the patella, its quadriceps and patellar ligaments and the detached tubercle; then passing tongue through a buttonhole in upper aspect of joint capsule. The detached structures thus fall into normal line where they are retained by sutures; tubercle is fixed by screw to new site on tibia; area denuded by dissection of tongue is covered by approx-

imation of margins; semilunar skin incision closed. Immobilization in plaster for 40 days. Walking permitted after 2 months. Functional result very satisfactory in both knees; walking much improved. Flexion of knees regained slowly; at end of 12 months could flex only to right angle on one side, better on other side.—*Roades Fayerweather, M.D., Baltimore, Md.*

THE TREATMENT OF RECENT FRACTURES. **Frank E. Peckham.** *Amer. Jour. of Elec. and Radiology*, June, 1922.

The author says that fractures must be considered primarily from a mechanical viewpoint and that if surgery should be found necessary in any case that it must be used as an aid to mechanics. Instead of forcible manipulation to reduce fractures, which often fails and gives the excuse for unwise open surgery, he employs mechanical appliances which act as both the reducing and the permanent holding mechanism. He makes frequent radiograms to show position of fragments and progress of union. In fractures of the surgical neck of humerus he employs traction and countertraction by a splint which holds the flexed forearm pointing straight forward and the arm by the side. Movements and other physiotherapy are begun as soon as union will permit. In fractures of the femoral neck he uses the usual weight and pulley extension on leg with counter-extension by another weight and pulley attached to a perineal strap. When the limb is pulled down to normal position after a few days he adds internal rotation of limb by adhesive straps and a T splint. No weight-bearing until sixth or seventh month.—*R. W. Billington, M.D., Nashville.*

OPERATIVE TREATMENT OF CERTAIN FRACTURES OF FEMUR, HUMERUS, AND FOREARM. E. W. Ryerson, *Southern Med. Jour.*, June, 1922.

The author uses Whitman's method for fresh fractures of neck of femur and the bone peg for ununited cases, exposing fully and freshening ends of fragments. Fractures of shaft of femur are treated by Thomas splint and Balkan frame. Open operation is rarely required, but more often in transverse than oblique fractures. He uses a short intramedullary peg of beef bone to prevent lateral displacement and maintains alignment by the Thomas splint. Autogenous graft is used in ununited cases. He also uses the intramedullary beef-bone peg frequently in fracture of both bones of forearm, many of which cannot be held in good position by external splints. He believes that very few open operations on fractures are required if the surgeon knows how to use and has the proper kind of external appliances; that very few communities are at present equipped with the essentials for proper handling of fractures, and that disabling fractures of the femur and other important bones should be as well treated as are diphtheria and appendicitis.—*R. W. Billington, M.D., Nashville.*

PHYSIOTHERAPY IN THE AFTER-CARE OF FRACTURES. H. E. Stewart, *Amer. Jour. of Electrother. and Rad.*, June, 1922.

The careful application of physiotherapy, chiefly the various forms of heat and manipulation, aid markedly in the early return to function in the cases of simple fracture. In complicated fractures other types, such as ultra-violet

ray to sinuses, ionization of scar tissue, sinusoidal current to restore muscle tone, etc., are helpful when properly applied. No surgeon can afford not to employ these measures. They are to be used as an aid to, and not a substitute for, surgery.—*R. W. Billington, M.D., Nashville.*

OTHER TRAUMATA.

A Case of Traumatic Myositis Ossificans. S. L. Bhatia, *Indian Medical Gazette*, March, 1922.

The author describes a case of traumatic myositis ossificans occurring in a soldier twenty-four years of age, in the Indian service, treated at the Indian General Hospital, at Bombay.

The patient was kicked by a horse in the left thigh, with resulting huge painful swelling, which after two months gradually tended to lessen in size, but continued to cause a limp and dull aching pain when walking.

The x-ray examination showed a large, irregular bony mass which seemed to be periosseous and apparently arose from an old hemorrhage affecting the quadriceps extensor muscle, associated with stripping of the periosteum and liberation of osteoblasts, with resulting new bone formation. The treatment was entirely palliative; ossification had become complete in two and one-half months. Because of the slow progress and slight disability, surgery was not urged. However, should the tumor increase in size later, the author would suggest excision of the entire tumor, together with some of the surrounding muscles, so as to be sure of excising all of the bone-forming foci.—*H. W. Meyerding, M.D., Rochester, Minn.*

Tennis Elbow. L. Cooke, *Indian Medical Gazette*, April, 1922.

The author discusses briefly the causes of tennis leg, cricket leg and rider's muscle and so-called foot-ball leg, and compares the findings of tennis elbow with the above. Generally speaking, these conditions are caused by a rupture of weakened muscles when put to unusual strain.

In tennis elbow the rupture of the supinator longus muscle is the probable cause of the disability. The fibrosis, periostitis, and proximity of the muscles with nerve results in considerable pain. The author advises against rest. However, he believes in adhesive strapping, massage, and "carrying on"; even moderate tennis is allowed. The strapping or bandaging about the elbow prevents undue movement at the elbow and allows the player to use the arm, playing principally from the shoulder. He recommends adhesive strapping from the outer surface of the arm from the external condyle nearly half way up the arm. (These straps should encircle only half the circumference of the arm, and one should overlap the other. The centre of each piece of strapping should be over the external supra-condyloid ridge.) Following the play the strapping is removed and heat is applied, followed by massage.—*H. W. Meyerding, M.D., Rochester, Minn.*

THE DIAGNOSIS AND TREATMENT OF SOME COMMON INJURIES OF THE SHOULDER JOINT. Robert W. Lovett, *Surg., Gyn., and Obstet.*, April, 1922, page 437.

This paper was read before the Chicago Surgical Society. It gives the anatomy of the shoulder-joint and the actions.

Under diagnosis it speaks of the importance of recognizing the difference between sprains of the ligaments, muscular strains, injury to the biceps tendon, synovitis, rupture of the supraspinatus tendon, and bursitis of the various bursae above the joint.

Under treatment, Dr. Lovett advises use of the platform splint in order to get abduction of the arm, which is essential in all cases of injury of the shoulder-joint. For adhesions he does not believe that massage or nagging, passive movements are advisable, as they are painful. Gradual abduction of the arm up to the point of pain is the best method. Occasionally abduction under an anaesthetic for a special block of the abduction may be necessary.

For supraspinatus tendon rupture, the sabre cut incision of Jones is best. The other condition demanding operation is chronic bursitis of the subdeltoid bursa which has not yielded to conservative measures, and also where there is calcification of the walls of the bursa.

He describes a condition which he calls irritable arm or false neuritis, which occurs in nervous, overworked women, which has symptoms wholly out of proportion to the cause. For treatment a sling and the gentlest possible massage and radiant heat.

(He makes no reference to the fact that a forward rounded shoulder is a potential of strain to the ligaments and capsule, and may keep up and even make worse a slight injury.)—*L. T. Brown, M.D., Boston.*

TRAUMATIC OSTEITIS OF THE WRIST. By Mark H. Rogers, M.D., *Boston Medical and Surgical Journal*, June 1, 1922.

Dr. Rogers has given us a clear and concise description of a bony lesion of which there is slight mention in literature.

There is pain, swelling, and disability, especially in dorsiflexion, which is chronic, and may or may not follow a history of injury. The symptoms subside with rest and immediately return when the wrist is used again. The x-ray shows a picture similar to tuberculosis of the semi-lunar or scaphoid bones, or may show a rarefied or shrunken condition.

He reports 4 cases, in all of which the bone was removed and a careful pathological examination made. No evidence of tuberculosis or other inflammatory condition could be found, but the cortex was thinned and much more fat and less osseous tissue than normal was present in the interior of the bone.

Function was perfect in one case, but not as good as before operation in others, and the symptoms had disappeared.

The paper is illustrated by 4 skiagraphic reproductions.—*H. A. Pingree, M.D., Portland, Maine.*

FRACTURE IN OSTEITIS DEFORMANS. By J. Anderson Smith, *British Med. Journal*, May 27, 1922.

The author reports a patient, aged fifty-one, with well-marked osteitis defor

mans, who slipped and fell over a cane, fracturing the upper tibia. The line of fracture was clear-cut, just as if done by a osteotome, and after apparent union in three weeks, the limb again gave way. Consultation was held after several weeks for delayed union, and amputation was considered. However, upon further consultation, prolonged fixation was advised and union occurred with stiffness of the knee. The patient also had retinitis pigmentosa and extensive psoriasis.—*H. W. Meyerding, M.D., Rochester, Minn.*

EPICONDYLITIS OF ATHLETES. Tavernier. *Revue d'Orthopédie*, January, 1922, page 5.

This lesion is characterized by persistent pain over the epicondyle of the humerus coming on after violent exercise of the arm. It is especially frequent in tennis players and in fencing masters.

The first publication on the subject was in 1896 by Bernhardt of Berlin, but it seems to have been forgotten for about ten years thereafter. Since about 1909 many cases have been reported. The author reports his own personal experience with the lesion. It began in June, 1920, with pain around the epicondyle of the right elbow. He was able to play tennis, but the trouble was worse after every game. In August it became so severe that the game had to be given up. There was never any swelling or ecchymosis. Complete extension of the forearm, of the hand and of the fingers caused severe pain. Reverse strokes in tennis, passes to the left in fencing, suturing skin with a Reverdin needle, and, in fact, all attempts at supination of the forearm brought out the symptoms very sharply. In September it was necessary to take a complete rest. All athletic games had to be given up, and it was not until January that the symptoms had practically disappeared.

The lesion is one of middle age, the statistics of Desplats showing 34 cases between 30 and 50 years of age, 11 over 50, and only 2 under 30. Those who are muscular and who play the game hard are most frequently affected. The symptoms are almost wholly subjective, the intensity of the pain being out of all proportion to the physical findings. It is not a spontaneous pain, but occurs only on motion or pressure over the epicondyle where the extensor communis digitorum takes its origin. Acute attacks usually subside with a week or two of rest, but the symptoms recur as soon as the exercise which causes them is resumed. The trouble may come and go in this manner for months or years and champions at tennis or fencing frequently have to give up because of it.

The pathology has been variously designated as rupture of tendon, abnormal relation of the radial head to the epicondyle, osteitis, and periostitis. Most of the observers who have written on the subject favor the idea that it is periostitis or an osteo-periostitis. Spurs and spicules on the epicondyle, and proliferation of the periosteum, have been demonstrated.

Diagnosis is usually simple and is made on the history and the characteristic localization of pain.

Rest is practically the only treatment necessary, but it must be prolonged many weeks after all symptoms have disappeared.—*William Arthur Clark, Pasadena.*

TUBERCULOSIS.

HYSTERICAL POTT'S DISEASE; SOME REMARKS ON DIAGNOSIS OF POTT'S DISEASE. Feutelais. *Revue d'Orthopédie*, January, 1922, page 37.

Several cases are reported to show that one or more of the classical symptoms may be absent in tuberculosis of the spine, and on the other hand the patient may present many typical symptoms of this disease but not have it at all.

The case which turned out to be hysteria was that of a girl of 18. Following an attack of the grippe in March, 1920, she had pain in the back and her physician noticed a fluctuant mass near the middle of the spine, which disappeared in a few days. The pain in the back persisted until she suffered almost continually. It was much less on lying down, but became worse again with movement. A kyphosis, slight but decided, was present from the twelfth dorsal to the second lumbar. The spine was tender throughout its entire length, but there was practically normal movement and the roentgenogram showed no lesion. In June there appeared a motor paralysis of the left leg and the patient had a violent nervous crisis which was strongly suggestive of hysteria. It was thought best to continue immobilization in plaster jackets, but just after a new cast was applied the patient had another very violent convulsive attack accompanied by cries and incoördinate movement. Finally the cast was removed, against the wishes of the patient, and she was given hydrotherapy on advice of a neurologist. In a few weeks she was completely cured of all symptoms.

Another case (boy of 7) showed a voluminous abscess in the left inguinal region, without pain, which on puncture yielded the characteristic creamy pus, and appeared to be a psoas abscess. However, there was no kyphosis, roentgenogram of the spine was negative, and movement in the back normal.

Five months later the abscess recurred and ruptured spontaneously, but there were no spinal symptoms. When seen a year later the child was completely cured and stated that the abscess had disappeared about eight months previous.

A case illustrating Pott's disease without any painful symptoms was that of a girl of 7, who had a kyphosis in the spine, muscular spasm of the vertebral column, and the characteristic lesion as demonstrated by the roentgenogram. In spite of all this, the child never complained of pain.

Another patient, 28 years old, after suffering several years with pain in the back and legs, finally developed a complete paraplegia. This disappeared after 14 months of immobilization. In spite of the facts that the roentgenograms were negative and the spine showed no kyphosis, this was regarded as a case of Pott's disease because no other disease could be demonstrated and the symptoms yielded to simple immobilization without any medication. — *William Arthur Clark, Pasadena, Calif.*

METABOLIC LESIONS.

OSTEITIS FIBROSA OF THE OS CALCIS AS A CAUSE OF TYPICAL CALCANEITIS. H. J. Bettman, *Zeitschr. f. Orthop. Chir.*, B. XLII., H. 5., S. 309.

The case reported is the only one appearing in the literature.

CASE: Girl of 18, in perfect health, complained of pain on the entire calcaneus on pressure and when weight-bearing. No abnormalities on the skeleton; even very little on the affected os calcis, except a slight thickening, apparently the result of a previously attempted, but unsuccessful, operation. The radiograph is typical of an osteitis fibrosa (print accompanies article). The unsuccessful treatment consisted in some form of surgical procedure, the details of which could not be obtained by the author, and in the application of a brace and shoe, both of which were to guard against weight-bearing pain, but which were not efficient.

The patient has not submitted to either operative or conservative treatment, so that the fate of this rare and interesting pathological condition cannot be traced.—*A. Gottlieb, M.D., Los Angeles, Calif.*

COXA VARA. René Bloch, *Jour. de Chirurgie*, July, 1921.

This is the second article in a contribution entitled "Fractures of the Neck of the femur and Coxa Vara in Infancy and Youth." The author discourses on various aspects of the subject, illustrating his remarks with reports of numerous case records, culled from medical literature and unreported cases. Nothing essentially new is added to our knowledge of the subject. The feature of the article is the inclusion of numerous, semi-schematic x-ray tracings, based on the study of which the author recognizes three anatomical types of the deformity, and points out the possibility of diagnostic errors in misinterpreting certain appearances that resemble fracture of the neck. The division into types is according to that portion of the femoral neck in which the downward incurvation has originated: juxta-trochanteric, when situated at the origin of the neck; medio-cervical, when at the mid-region; juxta-capital, when at the junction of neck and head. In the medio-cervical type sufficient atrophy of the neck may have occurred to give the x-ray appearance of an apparent solution of the continuity, but the condition is to be distinguished from a fracture of the neck by the absence of any relative displacement of the two halves of the neck. Pathological fractures do sometimes occur where there has been a pre-existing coxa vara, and are to be recognized as such by the incurvation of the two fragments plus the loss of alignment. In the juxta-capital type the condition may be mistaken for separation of the epiphysis. With respect to etiology, prolonged, or "late," rickets is believed by the author to best explain the cause of the deformity. In its incipience, recumbency with continuous extension is recommended; in the confirmed cases, correction by subtrochanteric osteotomy. —*Roades Fayerweather, M.D., Baltimore.*

THE HUMORAL SYNDROME OF GOUT. A. Chauffard, *Brit. Med. Jour.*, May 13, 1922.

This is one of a series of exchange lectures between the Faculty of Medicine of Paris and the University of London. The Folin and Denis method for determining uric acid in blood has been modified by A. Grigaut and the normal figure of uric acid was found by Grigaut and the author to vary between 40 and 50 milligrams per liter of serum; hyperuricemia commences above this. In 27 cases of gout, the average of all figures obtained was 0.094 gm. Experiments designed to clarify the rôle of the liver in retaining uric acid brought

to it by the portal blood consisted of parallel analyses of portal and hepatic blood. In a series of observations on dogs receiving diets rich in nucleic acid, the proportion of the uric acid of the portal blood arrested by the liver averaged 83 per cent. In the fasting state and on a milk diet no difference was found between the afferent and efferent liver blood. A uricolytic insufficiency of the liver appears to be one of the most important factors in the production of exogenous hyperuricemia.

Hypercholestrinemia was found to accompany hyperuricemia in the 26 cases of gout studied by the author with F. Brodin and A. Grigaut. The average cholestrinemia determined was 2.25 grams per liter, while the physiological average is given as 1.70. It is thought that the excess of cholestrin is attributable to the liver. The coagulum obtained by the action of trichloracetic acid on serum often shows, after standing, a blue coloration indicative of excess bilirubin. The double evidence, hypercholestrinemia and hyperbilirubinemia, is evidence of the insufficiency of the hepatic functions in gout.

In gouty tophi, deposits of cholestrin occur together with those of uric acid. In a tophus of the heel, 8.5 per cent. of uric acid and 2.1 per cent. of cholestrin were found. The acute crisis of gout is considered analogous to acute attacks of asthma, urticaria and migraine, *i. e.*, a local serologic shock of an anaphylactic nature. Hyperuricemia is taken to be the potential exciting cause for this, capable under the action of a provocative agent such as errors of diet, dampness or cold, to provoke the local or elective shock, active local vascular dilation, painful reaction of sensory nerves, and local precipitation of sodium urate in the region of the inflamed joint.—*R. M. Wilder, M.D., Rochester, Minn.*

Experimental Rickets in Rats. V. Korenchevsky, *N. Y. Med. Jour. and Med. Record*, May 17, 1922, page 612.

The writer says that he and others have produced experimentally typical rickets or osteomalacia in different ways. He asks, do these results solve the problem of rickets? He says, certainly not. It is necessary first to prove that all of these play a rôle in the etiology of human rickets. The experimental results serve only to indicate some of the possible ways in which the problem might be solved. He says his experiments have shown that the Vitamin A deficiency alone is capable of causing rickets. They also indicate the importance of calcium deficiency, especially in combination with deficiency of Vitamin A.

He says that up to the present time there have been too few attempts to treat rickets by the administration of a combination of lime salts with Vitamin A, and perhaps oral administration is unsuitable on account of the production of calcium soaps. Hence he suggests that subcutaneous injections may give interesting results.—*L. T. Brown, M.D., Boston.*

Osteochondritis Deformans Juvenilis of Hip. Lance, Andrieu and Cappelle, *Jour. de Chirurgie*, November, 1921.

The subject is dealt with under two captions: (1) Evolution and late results. (2) Relation to hereditary syphilis.

Remarking that certain writers state that Legg's disease sometimes or generally induces coxa vara in adolescence, others that it is the origin of osteoarthritis in adults, the authors sought to investigate the late results in their own cases. Of these they could collect but 5 for examination. The onset in the earliest case dated back 14 years; in the latest case, 7 years. All had received appropriate treatment during the juvenile, active period, but with interruption in two cases; the other three had been given extreme care. Upon reëxamination at this later date all five cases were found to present, in varying degrees, similar clinical as well as anatomical abnormalities, with marked deformations of the hip, the whole conforming to a recognizable type, characterized as follows:—

Anatomically: (1) A flattening and spreading-out of the entire epiphysis of the head, as though, in a softened state, it had been uniformly mushroomed down over the thickened, but otherwise unaltered, neck, enveloping the upper portion of the neck just as a Basque *beret* (sort of Tam o' Shanter) pulled down to one's ears. This is demonstrated in the lateral x-ray views; (2) direction of neck is unaltered; no coxa vara; (3) the superior aspect of the head has been levelled to a horizontal plane; (4) acetabulum deepened, and flattened in roof, in conformity to altered head; (5) some deformation of pelvis. These appearances are well shown in the semi-schematic x-ray tracings.

Clinically: All five cases limped, as result of varying limitations of motion, slight shortening, and muscular atrophy. All, in varying degree, had experienced recurring attacks of joint pain.

The authors conclude that Legg's disease is not to be interpreted, however, as a juvenile form of osteoarthritis deformans; it presents essential differences from the latter. They believe, on the other hand, that it does, like some other juvenile hip conditions, frequently provoke, later on, osteoarthritis of a certain type. Attempting to confirm their belief that this type is recognizable, *per se*, they report here 6 cases of osteoarthritis of the hip encountered in examination of candidates for reclassification in the French army. In clinical aspects, and in x-ray appearances, these joints conformed to the type above described. (The tracings of these joints are reproduced in this article, and resemble in a striking way the tracings of the late results in the authors' 5 cases.) Inquiry into the past history of these soldiers indicated that all had had childhood hip affections very suggestive of Legg's disease.

The second division of this article is concerned with a discussion of the resemblance of the early lesions in Legg's disease and the hip manifestations of inherited syphilis. Though far from convincing, this argument is interesting and demands consideration. The authors, themselves, venture only the conclusion that certain cases may have their origin in inherited syphilis. In this connection reports are included of 5 cases of hip affections, diagnosed as hereditary syphilitic, in children from Ombrédanne's clinic. Actual proof of syphilis was obtained in but two of these cases, but in all five anti-syphilitic treatment was followed by a rapid cessation of clinical signs and symptoms, with restoration to more or less normal x-ray appearances. This, of course, is in marked contrast with the evolution of Legg's disease, as heretofore observed. The reader naturally suspects that in spite of general similarities this group of five cases may have been wrongly identified with Legg's disease; yet he may do well to agree with the authors that, as yet, one cannot entirely reject

the possible identity of the two conditions. It appears from reports of their observations that the final prognosis in Legg's disease cannot include always a *restitutio ad integrum*, and may, indeed, require serious reservations. This prognosis would be improved greatly if it could be shown that syphilis was the origin of the hip disturbance. In any doubtful case the therapeutic test is certainly indicated.

In spite of its lack of finality, this article is worthy of attention, both by reason of its report of late results in treated juvenile cases, and also for its comparative study of anatomic deformations.—*Roades Fayerweather, M.D., Baltimore, Md.*

GROWTH PROBLEMS FOLLOWING OSTEOMYELITIS OF ADOLESCENT LONG BONES. Kellogg Speed. *Surg., Gyn., and Obstet.*, April, 1922, page 469.

An interesting paper discussing the problem of what to do when from osteomyelitis there has been an impairment of the growth of one epiphysis, as, for example, in the lower leg with the resultant deformity which comes as the uninjured part continues to grow. For treatment of this he has adopted the following rules:

I. Remember the law of nutrient arteries in relation to growing long bones, *i.e.*, the nutrient arteries are directed toward the elbow and from the knee, and the epiphysis toward which the artery is directed unites first. The fibula is an exception, of course. Consequently the lower end of the femur, the upper epiphysis of the tibia, the lower epiphysis of the radius and ulua, and the upper epiphysis of the humerus all unite last in their respective bones and must be the most guarded.

II. Unless a bowing deformity in the leg or forearm tends to manifest itself rapidly and to cause great loss of function or threaten skin necrosis, splint correction of the extremity for at least a year is favored.

III. If both clinical and x-ray examination during the course of the year show that the bone is arrested in growth, a shaft resection of the companion bone remote from the epiphysis is performed to equalize the length. Simple means (kangaroo tendon) of holding the resected ends in apposition are used, followed by a firm splint until union takes place.

IV. If the child is young (many years and inches of growth expected) after 2 or 3 years when it is quite positively established that the epiphysis of the damaged bone has ceased all growth and is obliterated, the analogous epiphysis of the fellow bone may be excised (epiphysectomy) to stop its overgrowth. Each bone then grows at an equal rate from the remaining epiphysis and there is no fear of subsequently appearing bowing deformity. Length deformity will persist.—*L. T. Brown, M.D., Boston.*

MISCELLANEOUS.

OPERATIVE TREATMENT OF TUBERCULOUS SPONDYLITIS. Bachlaender. Beitr. z. klin. *Chir.*, Bd. 124, H. 3, p. 655.

In regard to the question of judgment as to whether ankylosis of the vertebrae by means of a bone graft should be done for tuberculosis, there are cases of importance which by autopsies furnish the end-results of the transplant. Up to now there have been two cases of Meyer from Biesalski's clinic and one case

of Görres, examination of which showed absolutely firm bony union between transplant and spinous processes.

The author now reports the case of a patient who died eight weeks after operation. The surface of the transplant, although not covered with periosteum, was firmly united by bony growth with the spinous processes, while the periosteal side of the grafts was not yet firmly united even on the free border. It was, nevertheless, impossible to loosen the transplant from its union with the spinous processes. In forward and backward bending motions the transplant proved to be an absolute entity with the vertebral bodies. On the other hand, however, rotation was present in the lower parts which might easily lead to a fracture of the transplant. The author draws the lesson from this that rotation movements must be avoided and that a corset cannot hinder rotation.—*Armin Klein, M.D., Boston.*

End-Results of Operation for Dupuytren's Contracture. Dr. A. Bruce Gill, *Annals of Surgery*, April, 1922, p. 504.

Dr. Gill, who reported a method of operation for contracture of the palmar fascia in the *Annals of Surgery* for August, 1919, now presents the end-results three years later. These are said to be excellent, with no return to the contractures and with little or no finger stiffness, the latter being largely caused by the prolonged splinting which follows the usual operation by tenotomies. His operation involves the complete excision of the contracted palmar fascia and its replacement by a free fat transplant from the thigh.—*J. A. Nutter, M.D., Montreal.*

Treatment of So-Called Sciatica. J. A. Nutter, *Canadian Med. Assoc. Journ.*, May, 1922.

Nutter says that the large number of patients afflicted with leg pains and pains in the distribution of the sciatic nerve coming of late to the Montreal General Hospital has given him special opportunity to study the causes and treatment of these distressing conditions. The conception of Gowers that practically every case of sciatica is a true neuritis, he says, is being superseded by the belief that most instances of sciatica are really those of referred pain, especially from the neighboring joints, the lumbosacral, sacroiliac and the hip-joints named in the decreasing order of their frequency as offenders. He considers that 80 to 90 per cent. of cases are those of referred pain.

The treatment is medical and mechanical, the former being directed to the eradication of sources of infection, the regulation of the diet with low protein content, the giving of salines, and the local application of heat with massage. For sacroiliac strain he advocates the use of a flannelette spica made to bind the pelvis and hips very tightly together. In women a special corset with tight lacing over this region is recommended. Other measures, such as fixation of the hip-joint in plaster or otherwise, are used when this region is considered the source of the trouble. Nutter is probably right, that a large proportion of these typical joint pains are called sciatica, but we cannot believe they are often so considered by careful diagnosticians.—*C. A. Parker, M.D., Chicago.*

CHANGES IN FINGER NAILS AFTER RHEUMATIC FEVER AND TUBERCULOSIS. William H. Rosenau, *Jour. A. M. A.*, June 10, 1922, p. 1783.

Dr. Rosenau gives an interesting discussion of his observations at Johns Hopkins and Pirquet Kinder-Klinik in Vienna, relative to changes in finger nails after rheumatic fever and tuberculosis. His findings, in brief, are given in the following: (1) Small, circumscript depressions (pocking, stippling) occur in the nails following acute rheumatic fever and chorea in approximately 95 per cent. of the cases, particularly when heart complications are present. These changes are temporary and may disappear, to reappear after a recurrence of the same disease or some other infectious disease. One may see these changes as late as fifteen years after the last attack of rheumatic fever. These changes do not appear, as a rule, before six weeks have elapsed after the patient is taken ill, and often appear at a later date. The earliest time of their appearance is five weeks. These depressions are not infrequently associated with horizontal furrows, most often incomplete, and are not uncommonly seen together with lengthwise furrows, complete and incomplete. These changes, occurring in the absence of active tuberculous disease, and with an associated heart lesion, are confirmatory, though not definite evidence, that the patient has passed through an attack of acute rheumatic fever or chorea, and that a heart lesion if present, is probably rheumatic in origin. (2) These changes also occur in active tuberculosis in 70 per cent. of the cases, but they are often associated with transverse and longitudinal grooves and clubbing of the finger nails. (3) The depressions have been found in 4.5 per cent. of control cases in which no definite etiology could be ascertained, and they have also been found occasionally after a variety of diseases, such as scarlet fever, smallpox, empyema, typhoid, and Hodgkin's disease.

The author points out that the nail grows at the rate of .1 mm. per day. The nail completely recovers itself in 80 to 90 days in children, and in 120 to 132 days in adults.—*Voigt Mooney, M.D., Pittsburgh.*

INTERMITTENT CLAUDICATION DUE TO CARDIAC HYPOPLASIA. Serko, *Wiener Klin. Woch.*, Feb. 2, 1922.

A 13-year-old boy, negative history in infancy, started to walk at the age of two years, and then walked with difficulty because of apparent fatigue. As the child grew older, he became more abnormally exhausted and could walk only a few steps without collapsing. On examination cardiac action was found to be accelerated (120), and on ten knee bendings, 160.

The radiograph showed an unusually small heart with a narrow aorta. A radiograph of a normal 8-year-old boy showed the heart to be about one-third larger than that of the patient.

There is no doubt that the congenital narrowing of the vascular system and the hypoplasia of the heart were the causes of the intermittent claudication in this case.—*Armin Klein, M.D., Boston.*

REPORT OF PROGRESS IN ORTHOPAEDIC SURGERY. M. N. Smith-Petersen, M.D., *Boston Medical and Surgical Journal*, May 18, 1922.

Dr. Smith-Petersen has taken as his subject the "Report of Progress in Orthopaedic Surgery" as published in the *Archives of Surgery*, January, 1922. The author has given such a concise and matter-of-fact review that an abstract here seems useless and the reader is referred to the original paper. Its conservatism and brevity are to be commended and it covers pretty thoroughly the whole field of orthopaedics.—*H. A. Pingree, M.D., Portland, Maine.*

THESIS UPON THE SUBJECT OF RADIOGRAPHING THE SPINE AND PELVIS. H. J. Suggars, *Archives of Rad. and Electrother.*, May, 1922.

This article gives details of making radiograms of spine and pelvis, and is therefore of interest chiefly to the x-ray operator. Adjustment of apparatus, proper posing of patient and placing of plate so as to get best results in the different regions, are points discussed at length. There are also practical points on developing and printing. It should be read in full by those doing such work. —*R. W. Billington, M.D., Nashville.*

ATYPICAL FORM OF OSTEOCHONDRITIS OF THE HIP. Nové-Josserand. *Revue d'Orthopédie*, March, 1922, Page 193.

Although the typical picture of osteochondritis of the hip is now well known, there are some variations to which attention should be directed. Calvé, Mérine, and others regard the affection as an epiphysitis, but numerous records of involvement of the acetabulum and neck of the femur show this conception to be too narrow and exclusive. Mouchet has called attention to three cases with irregularities of the acetabulum, and the author found that part of the joint involved, slightly but clearly, in five out of eight cases.

One of the author's cases was under observation in 1900 and at that time a diagnosis of beginning tuberculosis of the hip ws made, but in the light of present knowledge there can be no doubt, from the clinical history and progress, that it was a case of Legg-Perthes disease. The symptoms, which are described in detail, form the characteristic picture of this disease, but the roentgenogram showed in addition to the typical flattening of the femoral head, an involvement of the roof of the acetabulum. The bone here was irregular in outline and overhung the femoral head. Decalcification was also evident. The lesion in the ilium appeared before that of the head and was the predominant lesion throughout the course of the disease.

Another case, bilateral, showed decided acetabular changes on both sides. On one side the cavity was hollowed out in its lower half and on the other side the upper half was more shallow than normal, due apparently to erosion of the upper margin. Both femoral heads showed separation of the articular cartilage into segments and flattening of the normal dome. These changes were shown by roentgenograms of about nine months interval to be progressive, which observation disproves for this case at least the idea of a congenital malformation.

Case 3 showed widening and flattening of the acetabulum, bilateral, also decalcification of the bone over the upper part of the acetabulum. Flattening of the femoral head was also evident on both sides.

It has been easier to admit involvement of the femoral neck than of the acetabulum in cases of osteochondritis. A decalcification of the neck, resulting in a coxa vara, is apparent in a large number of cases. In one case, a boy of nine, a limp in left hip appeared without pain, but accompanied by limitation of abduction and internal rotation. Roentgenogram showed diffuse decalcification in the neck, the head and acetabulum appearing to be normal. After three months in a walking splint the symptoms had subsided. The neck became recalcified, but a slight coxa vara persisted. Two other cases showed very much the same thing except that in one of them no coxa vara developed.

This involvement of the femoral neck resulting in coxa vara is probably the explanation of the deformity usually spoken of as adolescent coxa vara. It is concluded that the three deformities or diseases, osteochondritis, arthritis deformans juvenilis, and adolescent coxa vara, are but varieties of the same pathologic process. The different age at which the disease appears determines the part most affected. The three cases with cervical involvement were 9½, 11, and 13 years of age, an age considerably older than cases with osteochondritis, involving the head alone, and at which the relative density of the epiphyseal cartilage is less than the articular cartilage.—*William Arthur Clark, Pasadena, Calif.*

A Case of Ossification of the Subacromial Bursa. Coulomb. *Revue d'Orthopédie*, May, 1922, page 251.

A woman of 32 had suffered for about 8 years with pain in the right shoulder, more or less acute, and augmented by movements, especially abduction of the arm. Finally the pain became almost continuous and she carried her arm in a sling. The deltoid was atrophied. There was hyperesthesia over the distribution of the circumflex nerve, and the biceps was irritated throughout its entire length. Rotation and circumduction were limited and attempts at abduction caused intense pain. A clinical diagnosis of periarthritis scapulo-humeral was made, and confirmed by the roentgenogram. The bones of shoulder-joint were normal, but under the acromion was a round, opaque mass about 2.5 cm. in diameter. At operation this was found to lie in the subacromial bursa and was made up of spongy bone with a small calcareous deposit in its center. Movement was begun in the shoulder about ten days after operation, and when seen a year later the patient was completely cured and much improved in general health.

This seems to be a rare case, especially when considered as a cure of periarthritis by operation. It was particularly favorable as an operative case, in that the trouble was localized in one bursa. Regarding the pathology, it is thought that it might be analogous to myositis ossificans, perhaps starting with a hemorrhage into the bursa.—*William Arthur Clark, Pasadena, Calif.*

Book Review

Artificial Limbs and Amputation Stumps.—A Practical Handbook by E. Muirhead Little, F.R.C.S., England. Consulting Surgeon to the Royal National Orthopaedic Hospital; Surgeon to the Royal Surgical Aid Society; Visiting Surgeon under the Ministry of Pensions to Queen Mary's Convalescent Auxiliary Hospital at Roehampton; Member of the Advisory Council, and one of the Minister's Advisers on Artificial Limbs. With Two Hundred and Sixty-Seven Illustrations. Philadelphia: P. Blakiston's Son & Co., 1922.

It is with great pleasure that we recommend the publication of this admirable little book in this country, immediately following its English printing. With the exception of the book by Broca and Ducroquet on "Artificial Limbs" and another small book by Huggins on "Amputation Stumps," there has been nothing modern published on this subject in the English language.

Mr. Little, in his capacity of Orthopaedic Consultant to the Royal National Orthopaedic Hospital and to Queen Mary's Convalescent Auxiliary Hospital at Roehampton during the war, has had a particularly rich experience in the prescription and supervision of limb fitting since the beginning of the war. This book embodies in a clear and detailed way his large experience. The major part of the book is devoted to a study of the various types of artificial limbs, which are reviewed in an interesting manner. In addition, he presents a complete description with illustrations of the official prostheses used by the British Ministry of Pensions. Mr. Little has himself been responsible for the development of a large number of these limbs and is able to speak with conviction.

The British Government, with about forty thousand cases of major amputations, has wisely devoted itself to developing its own selected apparatus to fit every type of case, and these models may be obtained from almost any of the English limb builders. The limbs used, particularly those for the lower limb, are in a general way superior to those obtainable elsewhere, and in this country (although before the war our limb builders were the best in the world), the models that have been developed on private initiative alone are not as good as those which have been developed since the war under the stimulus of Government research and coöperation on the part of limb builders and especially interested physicians.

The war has demonstrated the great ignorance of the average surgeon on the subject of artificial limbs. Those who are called upon to perform amputations must know the requirements of a good stump and how to obtain it, and in addition must be able to advise the amputé as to the best type of apparatus for him to use and where to obtain it. It is to be hoped that this book will do much to remove this present point of weakness. Its author is not to be questioned and it is to be recommended to every surgeon.—*P. D. Wilson* (Boston).